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AUTHOR Terman, F. E.; Higdon, Archie
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ABSTRACT

This study reviews engineering education in Florida and investigates programs and plans for engineering technology. A questionnaire was prepared to obtain statistical data on the engineering activities at individual institutions. Deans of engineering schools responded to the questionnaires and site visits were made by consultants to each school. Results indicated engineering education is of particular importance to the state of Florida due to industrial development. At the same time, Florida lags behind developments taking place elsewhere in the country and as a result now lacks the quality it should have. Florida has made a sufficient start in technology education. Recommendations suggest the establishment of one and only one 4-year engineering technology program at a large 4-year engineering college in the state. Appendices include related material. (MJM)

A Study of Engineering and Engineering Technology Education in Florida

by

F. E. Terman
and
Archie Higdon

Prepared for
Chancellor's Office
State University System of Florida
Tallahassee, Florida

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PREFACE

The late 50's and 60's were periods in which higher education in Florida focused its energies upon providing additional educational opportunities for high school graduates. In the State University System, this focus resulted in the establishment of six new universities for a total of nine, a number of professional schools, as well as satellite campuses in various forms. In the zest and heady atmosphere of expansion slight attention was paid to overall program planning, unit costs, or gross costs. Expansion was predicated upon the idea that an unlimited supply of manpower in almost all disciplinary areas was required, and that opportunities should be provided on a broad geographical basis to supply such requirements. The future fiscal consequences of commitments were ignored.

An attempt to examine the basic assumptions and the consequences of the policies which governed the expansion, to price the ultimate cost, and to give direction and checkrein to growth resulted in an overall planning document entitled The Comprehensive Development Plan of the State University System (CODE). Early in the writing of CODE, it became evident that future detailed planning was required for a number of disciplinary areas, and that it was essential to question and change some of the assumptions which undergirded the actions of the 50's and 60's. The requirement for such action was written into CODE as policy. The result has been a series of studies covering such subjects as laboratory schools and teacher education.

One of the obvious areas requiring early examination was that of engineering education. The requirement for engineers is limited, and the training which culminates in an engineering degree is expensive. Colleges of engineering had proliferated, and all but two of the existing universities had engineering programs. It was widely assumed that any new universities, including two in the planning stage, would include such programs as a part of their curriculum. In addition, the State University System had responded to public pressure and legislative edict for even more extensive educational opportunities in engineering by establishing a closed-circuit television network of centers throughout the State which offers graduate programs in engineering. This particular network is operated by the University of Florida and is entitled Graduate Engineering Education System (GENESYS). Following consultation with the deans of the colleges of engineering of the State University System, two outstanding and nationally recognized specialists, Dr. Frederick E. Terman and Dr. Archie Higdon, were selected to study and assess all dimensions of engineering and engineering technology education and to equate programs with emerging and projected needs for engineers and related professions. It was hoped that their report would give academic policy formulation increased objectivity, perspective, and comprehensiveness.

The report of Drs. Terman and Higdon followed a series of visits to campuses in the State and intensive study of available information. The preliminary report was reviewed by the deans of engineering to insure that the consultants would have access to all pertinent information and that errors of fact or assumptions could be challenged and corrected. The document which follows this preface is the consultants' final report. It should be pointed out that the report is to the Board of Regents and does not represent policy of that Board until the Board takes action on the report.

Significant decisions have already occurred which resulted in part from the work of the consultants. Florida State University has terminated its program in engineering science and abolished the College of Engineering Science. A study is underway which has as its end a restructuring of GENESYS in order that those unique facilities have broader utilization and that all universities have access to them. I am confident that the report will have other consequences as we take a realistic look at the manpower requirements for engineering and the most efficient and economical way of fulfilling these needs. The State's obligation to provide trained manpower and the benefits which flow to the State from providing educational opportunities must bear a more direct relationship to manpower requirements and to available funds. Dr. Terman's and Dr. Higdon's report justifies the high expectations which led to a request for their guidance and will be helpful in realizing our goals as their reports have been helpful to other states who have engaged their valuable services.

August 31, 1971

Robert B. Mautz
Chancellor

FOREWORD

This study was undertaken at the request of the Chancellor's Office of the State University System of Florida. The basic guidelines were to make a review of engineering education in Florida similar in character to studies that had been previously made of engineering education in California, New York, and Colorado.[1] In addition, it was requested that the existing programs and plans for engineering technology be reviewed, and advice given as to the proper way to handle this rapidly growing area of higher education.[2] Although the principal focus was on the public institutions, private schools were included in order to provide a complete picture.

The present report, which resulted from the above assignment, consists of essentially two parts: (*a*) Chapters 1-4, inclusive, dealing with engineering in Florida, written by F. E. Terman; (*b*) Chapters 5-7 dealing with engineering technology and related matters, written by Dean Higdon.

Procedures. The procedures followed in this study are similar to those that had been used in previous assignments. A "Questionnaire" was prepared for the purpose of obtaining statistical data on the engineering activities at the individual institutions; this was adapted from Questionnaires used earlier in the California and New York studies. After the Deans had received Questionnaires, but before they began to fill them out, a meeting was held at Tallahassee (February 12) attended by the deans of engineering, appropriate State officials, and Messrs. Terman and Higdon. This meeting gave a chance to get acquainted and also provided an opportunity to explain how the study would be carried out. The Questionnaire was reviewed to clarify points that might have been ambiguous. In addition, background information on engineering education in the United States was presented by Terman.

Higdon reviewed the salient characteristics and role of four-year programs in engineering technology and industrial technology, and outlined the nature of the information he would be requesting.

After the Questionnaires had been completed and sent to Terman, and other information requested had been received by him, Terman made individual visits to all of the schools offering engineering, and Higdon made visits to all of those schools that either now offer or are considering

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[1] F. E. Terman, A Study of Engineering Education in California, March 1968; F. E. Terman, Engineering Education in New York, March 1969; A. Higdon, M. R. Lohmann, and F. E. Terman, Education in Engineering and Engineering Technology in Colorado, August 1970.

[2] Arrangements were made with Dr. Archie Higdon to carry out this part of the study.

offering engineering technology and/or industrial technology programs. Higdon also looked at several of the engineering programs in the State, particularly the University of Florida.

On the basis of this background, a preliminary draft of this report was prepared and circulated to the deans of engineering and members of the Chancellor's Office. Subsequently, an all-day meeting was held in Tampa June 2 of the same group that met on February 12 to discuss and review the preliminary draft. At this meeting, there was ample opportunity to question viewpoints, statements of fact, and the general trend of conclusions. The discussion was extensive and at times quite lively.

The final report was then written. It presents the consultants' views and recommendations after taking into account and assessing all inputs that had been received from various sources.

After the survey was announced, the Florida Engineering Society expressed interest in the project. As a result, Terman and Higdon held a conference with E. R. Hendrickson, president of the Society. Mr. Hendrickson received a copy of the "Preliminary Report" at the same time as did the deans, and was present at the June 2 meeting in Tampa.

General Comments Regarding Engineering. Engineering education is of particular importance to the State of Florida because of its relation to the future of the very promising industrial development that is taking place in the State. At the same time, engineering in Florida faces serious problems. In the twenty years following World War II, engineering in Florida lagged behind developments taking place elsewhere in the country, and as a result now lacks the quality that it should have. Again, in spite of the large investment that has been made by public institutions during the past twelve years in: (*a*) establishing new engineering programs at four institutions, and (*b*) expanding the capacity of the University of Florida's College of Engineering, the needs of the State for engineering education are still only partially met.

The engineering portion of this report addresses itself to these matters.

Engineering Technology and Industrial Technology. Four-year BS programs in engineering technology and industrial technology are relatively recent developments, but are already meeting a very important educational need. The technologists that these programs graduate lie between the engineer and the craftsman, and between the engineer and the administrator, respectively, and have an important role in industrial activities related to engineering. In fact these technologists perform many of the functions that have been traditionally handled by BS engineers.

Florida has made a sufficient start in technology education to generate experience that will be invaluable in future planning, but is not so far along that it is already committed to any overall State plan.

Florida hence has the opportunity to develop engineering technology and industrial technology in a way that meets the State's needs for geographical and subject matter coverage, while at the same time avoiding unnecessary duplication of programs and premature expansion of faculty.

Chapters 5-7 of this report analyze the present situation in Florida with respect to engineering technology and industrial technology, and conclude with a series of recommendations that set the stage for orderly development of these growing areas in the years immediately ahead.

The 1966 Study of Engineering in Florida. This is not the first time that engineering education in Florida has been reviewed by outside consultants. In the fall of 1966, a three-man panel spent a week visiting public institutions in the State, and prepared a report[1] based on these visits and the associated verbal briefings. The observations and recommendations in that review which are relevant to the present report are summarized in Appendix C. The appraisal of problems and trends that existed in 1966 are reflected in the 1971 situation. In other words, this earlier study and the present survey can be fitted together without the need of reconciliation beyond adjustments resulting from events that have taken place in the intervening five years.

Frederick E. Terman

Archie Higdon

Consultants

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[1]William Everitt, Chairman, Paul Chenea, and Robert Saunders, Engineering Education Programs in the State Universities of Florida, 1966.

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Chapter 1: Engineering Education in the United States. The number of bachelor's degrees awarded in the US averaged slightly less than 40,000 per year during the 1960's, and for planning purposes can be expected to be approximately the same during the 1970's.

The proportion of BS engineers who go on for the master's degree has, however, been steadily rising and now exceeds 40% of those who receive the BS degree. The master's degree is now regarded as the preferred level of preparation f r the general practice of professional engineering, whereas 20 years ago the bachelor's degree served this function.

The doctor's degree has become an important factor in engineering in the last 15 years; it is the preferred preparation for those who plan a career in teaching, in research or advanced development, or in the practice of engineering at the very highest levels.

Dramatic changes have thus taken place in engineering in the last 20 years. While 10% of those graduating in 1951 continued their studies to the MS degree, 10% of those graduating 12 years later (1963) went on to the doctorate, and today at least half of the BS graduates take at least some graduate work. Thus the young engineers are now on the average far better educated than were their predecessors of 15-20 years ago.

Although there are many fields of engineering, about 65% of all engineers graduate in Electrical, Mechanical and Civil Engineering; if one also includes Chemical, Industrial and Aeronautical Engineering as well as those who graduate without designating a specific field, over 90% of all BS engineers are accounted for. Thus, as far as engineering education is concerned, engineering consists of a few mainstreams, supplemented by a substantial number of tiny rivulets.

Graduate study in engineering is dominated by the fact that most graduate students need financial assistance. Accordingly, the size of the full-time-on-campus graduate student body is controlled by the number of assistantships, fellowships, etc., available. These students are matched by an even larger number of graduate engineering students who hold full-time industrial employment and go to school part-time, either in the evening or in day courses. In this situation the relative importance of part-time graduate work grows as MS graduate work becomes increasingly necessary.

As the master's degree becomes more and more accepted as the appropriate preparation for full professional status in engineering, engineering schools that offer no engineering beyond the bachelor's level are disappearing.

Instruction costs in engineering are heavily influenced by enrollments. It can be shown that the minimum economic size is 40-50 BS degrees per year awarded by each independent undergraduate curriculum, and also the same number of MS degrees for each independent graduate curriculum. When a department of an engineering school is appreciably below this size, either at the BS or MS level, the instruction cost per student credit hour increases as a result of too many classes having low enrollments.

Doctoral programs need not be unduly expensive, provided there is an adequate MS program, and also provided adequate research grants and contracts are available to support the doctoral activity.

A survey shows that approximately 50% of institutions now offering the BS degree in engineering and 80% of those offering the MS degree are underpopulated with students to the point where they cannot make efficient use of the faculty teaching effort in their BS and MS programs, respectively.

Many entering freshmen planning to study engineering have not yet decided which field of engineering they prefer. Others who indicate an initial preference often change fields before graduation. It is therefore important that undergraduate engineering students have an opportunity to examine different fields while in college. When undergraduate numbers are too small to justify separate departments, the best method of handling the situation is to offer a single curriculum in General Engineering which provides some, but only limited, opportunity to specialize in a particular field. When enrollment is small, it is undesirable to focus on a single "stand-alone" undergraduate specialty because the above-mentioned uncertainty in students' plans makes the lack of flexibility of such a curriculum unattractive.

In spite of the fact that about two-thirds of all BS graduates are in three fields of engineering and over 90% are concentrated in six independent fields, there is a tendency to give more attention to minor fields than is justified. Further, when a school has many undergraduate engineering curricula, different departments commonly establish independent and overlapping introductory courses in a core subject such as fluid mechanics or computer science, even though the basic principles are the same irrespective of application. This tendency toward courses tailored to an imagined special interest is to be resisted.

Faculty productivity in teaching is most appropriately measured in terms of average number of student credit hours taught per faculty member per term. High productivity with light teaching loads can be achieved by giving professors the opportunity to appear before an adequate number of students in each class. Faculty PhD productivity is measured in terms of PhD's per faculty member per year. The best schools typically produce 0.5 or more PhD's per faculty member per year, counting assistant professors and higher in the base, but excluding visiting and part-time faculty (lecturers, adjunct, etc.).

The master's degree is typically awarded without a thesis by schools that have strong PhD programs. On the other hand, an institution that does not offer the doctorate in engineering should require a master's thesis at least for its full-time-on-campus students because the presence of student-faculty research activities on campus is educationally desirable.

Engineers are highly versatile, and as a consequence engineers graduating from college can always find jobs, although when jobs are scarce they may have to hunt for initial employment and then accept whatever is available. At the present time, things are slack, so that the quality of the jobs available to fresh engineering gradutes is below normal, but this can be expected to change with the economic cycle and the growing technological complexity of society. The present unemployment problem in engineering is heavily concentrated among older engineers who are expert in narrow specialties not now in demand, and who because of age and technical background are less adaptable to present-day needs than are younger engineers with more modern training.

Since World War II, this country has witnessed an unprecedented expansion of industries based on sophisticated applications of science and technology. Such companies are very attractive to communities desiring to strengthen their economic base. These growth companies depend upon advances in technology and live very close to the frontiers of knowledge. Their success is accordingly strongly dependent on the quality of their engineering personnel, and the extent to which these individuals keep up with a rapidly changing technology. Education is therefore an all-important component of raw material to these high-technology firms. However, educational opportunities are attractive only if they are of high quality. Second-class quality will attract and hold only second-class people.

Chapter 2: Engineering Education in Florida. Florida produces a substantially smaller fraction of the country's BS, MS, and PhD engineers than its proportionate share based on population. The University of Florida produces over half of the State's bachelor's and master's degrees, and all of the doctorates in engineering, although new public institutions are gradually becoming more important in the total picture.

Florida institutions offer curricula over a wide spectrum of fields. However, many of the BS engineering curricula and virtually all of the master's curricula available at Florida schools are underpopulated with students, and hence below the desirable size for economical operation.

Florida has more Ocean Engineering curricula than are necessary or desirable. It is recommended that the Chancellor's Office review the present programs in public institutions dealing with the ocean and devise a master plan for the future development of this broad subject at both undergraduate and graduate levels.

Graduate-level engineering education in Florida lacks quality. The only institution having any national visibility is the University of Florida, which ranks within the top 35 (but not in the top 25) institutions in the country in engineering. Undergraduate engineering in Florida is not distinguished as judged from the fact that only 3 of the 8 Florida institutions offering a bachelor's degree in engineering have ECPD accreditation. In some cases, this is due to the newness of the programs.

Nearly all of the sponsored research activity in engineering is at the University of Florida, which has a substantial program. The University of South Florida is a poor second, while the remaining schools in the State have virtually no sponsored engineering research. This is a further indication of weakness in faculty quality.

Florida has lagged behind most states in providing part-time programs whereby employed engineers can obtain a master's degree. However, a major step was taken with the establishment in 1965 of GENESYS, a closed-circuit, talkback television system that initially made graduate courses available to industrially employed engineers in Orlando, Daytona Beach, Cape Canaveral, and which has been subsequently extended to West Palm Beach and Boca Raton. This is an innovative development which is discussed at length in Chapter 3.

The level of interest in engineering on the part of undergraduate students studying at Florida institutions is substantially below that in the United States as a whole, or in the adjacent states of Alabama and Georgia. There is considerable evidence to indicate that many young Floridians interested in engineering go out of state for their undergraduate work. All of the public schools in Florida except University of Florida present a weak engineering image on the basis of this criterion.

The engineering schools of Florida are all underpopulated with students in relation to the available facilities, equipment and staff, and each would accept more students if qualified applicants were available. This applies to both undergraduate and graduate levels.

A characteristic common to all of the "four-year" undergraduate engineering programs at Florida public institutions is that they require more than the advertised 4 years for the average student to complete. It is recommended that the engineering curricula at the public institutions be revised so that at least half of the students in good standing will receive their BS at the end of 4 years, and could earn a master's degree in engineering at the end of a 5th year. Overlong undergraduate programs are both unfair to the student and expensive to the State.

Values of direct instruction cost per student credit hour and of productivity indices have been determined for the engineering colleges in Florida, and are presented along with comparable data on other representative institutions (Table 2-7). The resulting costs and indices are reasonable, but in general tend to be a little higher in cost, and somewhat lower in faculty teaching productivity than is fully justified on the basis of quality. This is particularly true with the University of Florida, where a very large enrollment is divided among so many curricula as to lose the economies normally associated with such a large number of students.

The junior colleges in Florida are becoming an important source of engineering students for the senior colleges, and the engineering deans expect that this trend will increase. Although there is general satisfaction with the quality of the pre-engineering graduates of the better junior colleges, it is not entirely clear that the articulation problem has been effectively worked out.

At the present time, only one of the five public institutions offering engineering has one or more undergraduate curricula accredited by ECPD. Such accrediting should be sought for at least one undergraduate curriculum at each school now unaccredited. While ECPD accreditation does not imply that the school is superior, it does indicate minimum standards have been met; thus lack of accreditation can be a matter of embarrassment.

Master's degree programs should be authorized as a matter of course once a bachelor's degree program is established and functioning.

Procedures for authorizing doctoral programs in engineering in public institutions in Florida should give special attention to the ongoing research activity of the faculty, particularly research supported by extramural grants and contracts obtained in open competititons, such as grants from government agencies. A new procedure should also be devised so that a faculty member in a department not authorized to grant the doctorate could sponsor a doctoral student on a tutorial basis in individual situations where the faculty member had an established reputation in his particular specialty, and was <u>already</u> carrying on a successful research program with outside sponsorship related to the proposed doctoral program. It is recommended that a procedure be set up for approving such "PhD special" programs on a student-by-student basis.

The public institutions of Florida attract very, very few out-of-state engineering students. Also, among the public institutions, Florida Atlantic, Florida Technological University, and South Florida cater to student bodies that are heavily local, whereas the University of Florida and Florida State do not. In contrast, the clientele of the private institutions are less local and also more out of state.

Florida has experienced a significant industrial development in recent years. This is based largely on national firms that have established design and manufacturing activities in the State, but which do most or all of the related research and advanced development elsewhere. A number of indigenous technology-oriented firms have begun to emerge in Florida in the last few years. While these are still small-to-modest in size, some appear to have promising futures and offer the possibility of upgrading the character of Florida industry. <u>Thus Florida has the potential of becoming a national center for high technology industry, but</u>

a stronger technological base than now exists is required to achieve this end result. Engineering education can influence the future, since strong engineering programs, including high quality and well-thought-out course offerings for part-time students, can raise the technological level of an industry in which the most important raw material is the quality of its engineering manpower. A start has been made in education to meet these needs, but there is much still to be done. Further resources devoted to engineering education should be regarded by Florida as a capital investment in the future of the State that will pay large dividends over the years.

Chapter 3: GENESYS. GENESYS is a system of closed-circuit talk-back television devised at the University of Florida to bring graduate-level instruction in degree programs to industrial employees in east central Florida. GENESYS emphasizes a normal classroom environment in the originating studio-classroom. The classroom action is transmitted to receiving points over leased circuits, and students at the viewing locations are provided with pushbutton microphones for talking back to the originating classroom. The students thus attending class via "electronic residence" do homework and take examinations concurrently with students in the studio classroom, and are found to perform as well on examinations as the students in the originating studio-classroom. GENESYS originally linked Gainesville with Cape Canaveral, Orlando, and Daytona Beach; subsequent extensions have been made to West Palm Beach and Florida Atlantic University. At each location away from Gainesville there is a Center, consisting of a building that provides viewing rooms, a studio-classroom equipped to originate a program, laboratories, computer facilities, library, etc. Several faculty members from the University of Florida are resident at each such Center. Each link of the system is capable of simultaneously transmitting one program in each direction, so classes can originate both at Gainesville and at the Centers.

GENESYS was an immediate success, and its concept has been widely copied by numerous educational institutions, though commonly with modifications. Thus, at Southern Methodist University, the viewing rooms are located directly in the industrial plants where the part-time students work, thereby eliminating the need to commute to a central point. At Stanford and elsewhere, the signals are broadcast directly into industrial plants. GENESYS has also stimulated the development of videotape techniques, in which classroom activities are recorded and then played back on a delayed basis in industrial plants; while this arrangement lacks the advantages of talkback, it still has proved to be quite successful.

GENESYS has had between 400 and 600 course enrollments each term since it was established and over the years has awarded a substantial number of master's degrees. Some 40 or more courses are offered each term, of which about 40% originate at Gainesville. To minimize commuting time, GENESYS class periods are 75 minutes long, so that a three-unit course meets only twice per week. In order to originate 20 classes from Gainesville with only one southbound channel, classes must begin at 6:30 a.m. and run until 10:20 p.m. Thus the GENESYS schedule does not fit into the regular schedule of Gainesville classes.

As presently conducted, GENESYS is a high-cost operation. Line charges are considerable; it is expensive to maintain the Centers; and further, GENESYS pays a substantial sum to the University of Florida College of Engineering for the privilege of placing on GENESYS "regular" UF classes taught by regular UF faculty.

At the time of its establishment, GENESYS represented a major innovation in graduate education; however, the system today is technically identical with the prototype system placed in use in early 1965, and as such has certain limitations. It does not bring the courses to the students, but rather requires students to commute to a central location in each geographical area. Since GENESYS class hours do not correspond with the normal class hours at the Gainesville campus, there is resistance to placing Gainesville classes on GENESYS. As a result, only about 40% of the instruction offered by GENESYS is provided by the University of Florida, although the principal academic strength in Florida at graduate level in engineering exists at Gainesville.

Since the initiation of GENESYS, new engineering programs have been established at public universities in east central Florida, but they and GENESYS operate as if the other did not exist. Again, the GENESYS clientele consists largely of large nationally based firms in the aerospace and electronics fields. There are other engineering activities in the State that are not being served by GENESYS; in addition, there are important geographical areas, notably Tampa and Miami, which GENESYS does not reach.

It is recommended that a program for revitalizing GENESYS be given high priority. In such a program, emphasis would be placed on such objectives as maximizing the number of industrial employees available as GENESYS students; making GENESYS courses more easily accessible to students; emphasizing quality of course offerings; encouraging interinstitutional cooperation; broadening the scope of offerings; interesting more companies and more engineers in this service; simultaneously reducing the cost to the State in relationship to the services rendered; etc.; etc.

These results could be achieved by broadcasting GENESYS signals (or using videotape recordings) to make classes available to industrial employees at their places of employment, by making the GENESYS schedule conform to the UF campus schedule, and then by exploiting the faculty quality present at UF by originating most of the classes at Gainesville. Interinstitutional cooperation should be developed in a way that will help the recently established engineering programs in public institutions improve their advanced undergraduate and MS degree level offerings, by drawing on strength existing at the University of Florida.

GENESYS costs can be minimized by putting on GENESYS only those classes that would be taught anyway on a university campus in the absence of GENESYS; by transferring GENESYS Centers to a local university wherever possible; by using interinstitutional cooperation to reduce the needs for staff expansion in the newly established engineering schools; by making increased use of lecturers from industry; etc.

It is recommended that the first steps towards a revitalized GENESYS consist of: (*a*) closing down the Center at West Palm Beach and instead broadcasting GENESYS signals to the West Palm Beach clientele, and (*b*) transferring the associated administrative activities to Florida Atlantic University, which could also broadcast GENESYS classes as well as originate classes for local broadcast. This plan has numerous advantages: (*a*) there is already a GENESYS outlet at FAU; (*b*) FAU is in a stage of its development where it would benefit greatly from interinstitutional cooperation; and (*c*) there is an industrial area to the south of Boca Raton not now served by GENESYS that could be reached by broadcasts from FAU.

Concurrently, it is recommended that an objective systems analysis study be undertaken to determine the best ways to improve the total operation of GENESYS throughout the State.

An intermediate step for implementation involves establishing a local broadcasting system at the University of South Florida for transmitting daytime graduate classes to viewing rooms in industrial plants to replace most or all of the present evening engineering classes being offered by the University of South Florida.

A revitalized GENESYS will call for a substantial but not excessive capital expenditure. However, the suggested plan would generate savings though reduction in operating costs and the avoidance of increases in academic budgets at cooperating institutions, which over a span of the order of five years would more than pay back the capital investment.

As interinstitutional cooperation develops, GENESYS must begin to operate as a utility that serves all interests in the State, rather than functioning as the private preserve of a single institution as at present. Accordingly, if there is to be a strengthened GENESYS program involving extensive interinstitutional cooperation, it is suggested that a GENESYS Commission be established whose membership would include representatives from the Chancellor's Office, from each cooperating engineering school, and from the general public. Such a Commission would establish policies with respect to budgets, transferability of academic credit between institutions and GENESYS, etc.

As interinstitutional cooperation grows, each participating institution will have both the opportunity and also the responsibility of seeing that industry located within its home service area is fully aware of the potential of the combined resources available through GENESYS and the local institution. Under no circumstances should there be competition between GENESYS and the local institution in the latter's home area. Each participating institution must establish a continuing liaison program with industry, with the engineering community, and with the general public in its home territory.

The modifications in GENESYS proposed above will provide industry with new educational values at little cost to industry, and at a net saving to the State.

The future of GENESYS is uncertain since it is facing large budget cuts. These could very well result in the curtailment or even a phasing out of GENESYS, since any reduction in quantity and/or quality of the present service is likely to start a downward spiral that would end with Florida's high technology industry receiving too little educational support to matter.

In this connection, if Florida cannot provide its high technology industries with strong educational support, Florida cannot expect such industries to flourish in the State.

Chapter 4: Review and Assessment of Engineering Education in Florida. Objectives for engineering education in Florida include (*a*) providing training that will prepare Florida residents for the professional practice of engineering; (*b*) providing opportunities whereby employees of Florida's industrial concerns can advance their competence through part-time degree programs; and (*c*) maintaining at least one public institution that has enough quality (and hence national distinction) to give leadership in engineering. The production of engineers for the purpose of meeting the manpower needs of Florida industry is not a high priority goal, since Florida industry can recruit the engineers it desires from all over the country.

The major issues of engineering education in Florida are enumerated and commented on in this Chapter. Some of these, such as the need for quality and the time required to obtain a BS degree, have been discussed previously. Others deserve a few additional words. Thus, public engineering schools in Florida have the plant capacity to handle any enrollment increases likely to occur for at least five years. In fact, if one could redo the past with the benefit of hindsight, there would now probably be only three instead of five publicly supported engineering programs in the State.

It would seem desirable to have a functioning Council of Engineering Deans in Florida which meets at least semiannually.

Advising of undergraduate engineering students could be improved. The need for improvement is indicated by the excessive length of time that the typical undergraduate student takes to obtain a BS degree. The situation is particularly unsatisfactory at the University of Florida, where the freshman and sophomore students have only minimal contact with the engineering faculty. The problem of handling junior college transfers and the articulation of the junior college curriculum with upper division engineering programs also needs more systematic attention than has as yet been given.

While a properly qualified MS degree candidate should normally receive his degree after three quarters of full-time equivalent study, it is not clear that this is the case. Further, as doctoral programs get established at the different institutions, the practice of requiring comprehensive examinations in addition to course work when the MS degree is awarded without thesis is open to question.

The engineering programs at the public institutions in Florida suffer from an unusually high incidence of classes with small enrollments. Unneeded courses of low popularity should be eliminated, and policies regarding cancellation of classes with small enrollments should be developed and vigorously enforced.

Florida Atlantic University. This institution is an upper division-only university, and as such is breaking a new trail in education, most particularly in engineering education. It has been doing very well to date with a single specialized engineering curriculum in Ocean Engineering. However, graduate work has been started in Ocean Engineering, as well as undergraduate curricula in Electrical and Mechanical Engineering; and until enrollment builds up in these new areas it may be difficult to avoid an overabundance of small classes. A revitalized GENESYS could be of substantial help in connection with these new programs.

The industry surrounding FAU is more strongly oriented toward research than is most industry in Florida, which should provide FAU with both a challenge and an opportunity.

Florida State University. FSU was the second public institution in Florida to offer engineering. It has a "stand-alone" true Engineering Science curriculum at both undergraduate and graduate levels. However, for reasons previously discussed, it has never developed a strong following, even though the program itself is adequate. The State plans to phase out this program at the end of 1971-72, while transferring some remainders to another public institution where there is a broader base of engineering.

University of South Florida. This institution offers a single General Engineering major which gives some opportunity to specialize in a particular engineering field. A steady year-by-year increase in enrollment has been experienced, and the undergraduate operation is viable from the standpoint of instruction cost and teaching productivity.

A master's degree in General Engineering is offered to a clientele that is largely part-time. The potential exists for a large part-time MS program in view of the substantial amount of industry in the area. However, geographical dispersion makes it difficult to serve the industrial employees from any one location, and it is suggested that regular daytime graduate engineering classes be broadcast from USF directly to industrial plants where the students work. Graduate offerings for such a system could be enriched by the use of videotapes from GENESYS classes, and by the use of adjunct faculty drawn from industry.

The USF faculty varies in qualifications from department to department. During the years ahead, the highest priority should be placed on strengthening the faculty to the point where the institution achieves some measure of national visibility.

Florida Technological University. In spite of its name, this institution is a general university, not an institute of technology. It offers a single undergraduate major in General Engineering similar to that at University of South Florida; the first freshman class entered in the fall of 1968. Good progress has been made to date, but it is too early to determine exactly how well the engineering program is taking hold.

Graduate work has been authorized beginning 1971-72. However, if the institution is to provide the comprehensive high-quality selection of course offerings required for the school to make a significant contribution to the educational needs of surrounding industry, it will be necessary in the first few years to supplement the FTU faculty by drawing heavily on both adjunct faculty from industry and on GENESYS courses.

University of Florida. This institution accounts for the majority of BS and MS engineering degrees and for all of the engineering doctorates currently awarded in Florida. Faculty quality is good, and has improved in recent years with the help of an NSF Development Grant. The institution has a sponsored research program in engineering considerably larger than those of all other Florida institutions combined.

Enrollment at undergraduate and graduate levels at UF is large, but is divided among 11, 13, and 10 fields at BS, MS, and PhD levels, respectively. This proliferation of curricula and departments results in low faculty teaching productivity and higher than necessary instruction costs. Also, faculty distribution among fields is unbalanced with respect to their relative importance, and several departments are patently overstaffed. It is recommended that during the next decade the Univeristy of Florida work toward (*a*) a consolidation of its degree programs; (*b*) a reduction in the number of degree programs, with corresponding reduction in the number of administrative units and number of courses offered; and (*c*) a distribution of faculty that is more in accord with the distribution of students being served. This is a long-term project, rather than a matter that can be legislated into immediate existence.

A number of factors have combined to cause Engineering at UF to verge on being overstaffed. The NSF Development Grant required substantial faculty expansion; the recent establishment of engineering programs at other public institutions within the State has kept University of Florida enrollments below projections; also, changes in undergraduate curricula which will let students gain BS degrees more quickly will reduce student credit hours per graduating student below previous levels and free teaching time. Again, GENESYS Centers discontinued because of budget cuts will result in resident faculty with University of Florida appointments being returned to Gainesville. The 1971-72 reduction in State appropriations for sponsored research in engineering will also release faculty time.

Engineering at UF suffers from over-rigid line-item budgeting, over-reliance on general staffing formulas, etc. This thicket of regulations concentrates on protecting against possible abuses, rather than providing incentives and rewards for doing the right things, and puts a premium on gamesmanship.

Embry-Riddle Aeronautical University. This is a very highly specialized private institution concerned with various aspects of aviation. In addition to other curricula, it offers a BS program in Aeronautical Engineering. Nearly all Embry-Riddle students are from out-of-state, so the institution interacts only nominally with engineering education in the rest of Florida.

Florida Institute of Technology. FIT is a private institution that concentrates on engineering and applied science. It offers BS and MS degrees in Electrical Engineering and Space Technology. The latter is to be transformed into a bona fide engineering program with a Mechanical Engineering emphasis. The institution caters to a substantial part-time, locally employed clientele at both undergraduate and graduate levels; in addition, it has a considerable number of full-time-on-campus students who are mainly Florida residents. It is recommended that the possibility of tying FIT into GENESYS be explored.

University of Miami. This private institution possesses a moderate-sized undergraduate engineering operation distributed over 5 ECPD-accredited curricula. In recent years it has also awarded MS degrees in four fields. Although University of Miami offers the only engineering program in the Miami area, it has benefited very little from this situation, since only a small fraction of the students live within commuting range of the institution (and most of these are reported to be Cuban-born); approximately half of its recent graduates are listed as from out of state.

Engineering is regarded within the University of Miami as a marginal operation and discussions are currently taking place with respect to its future. There is the probability that some changes will be made to streamline and simplify the activity, and perhaps simultaneously deemphasize it. Various possible future directions for the school are discussed.

Chapter 5: Engineering Technology Education in the United States. Engineering, engineering technology, and industrial technology are defined. Engineering technology lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer. Industrial technology occupies the midground between engineering and business administration. Graduates of two-year technology programs are called "technicians," and graduates of four-year engineering technology programs are usually called "technologists."

A typical four-year technology curriculum contains approximately two-thirds as much mathematics, physical science, and engineering science as does a BS engineering program, and the mathematics begins with college algebra rather than with the calculus. About 70% of a four-year engineering technology curriculum can be classed as math-science-technical. In contrast, about 50% of a typical industrial technology curriculum is devoted to math-science-technical subjects, with the science-technical content being normally quite low compared to an engineering technology curriculum. Students of technology programs generally cannot transfer to an engineering program without remedial work in mathematics, physical science and engineering science. A pre-engineering or an engineering transfer program is not the same as the first two years of an engineering technology program.

Faculties for BS programs in engineering technology should have a majority of engineers with practical experience relevant to the curriculum. Programs in industrial technology are less dependent upon engineers, and may be staffed largely by industrial arts graduates and practitioners from industry, including some who have had management training or experience.

There is a consensus that for the next movement upward in production, industry will need an increased input of technicians and technologists. The demand for technologists will be great, and to train an adequate supply will require a new educational development possibly as extensive as one-third the present operation in engineering colleges. This is a task that may take more than a decade to achieve.

Chapter 6: Engineering Technology Education in Florida. Enrollment and degree data are given for four-year programs offered in Florida in engineering technology, industrial technology, and other closely related areas. The latter include programs in Systems Sciences at the University of West Florida, and University of Florida programs in Building Construction and Mechanized Agriculture.

A committee of the Associated General Contractors of America has recommended a curriculum in the field of construction that contains approximately 70% math-science-technical courses, thus corresponding almost exactly with the standard engineering technology pattern. The curriculum in Building Construction at the University of Florida is 66% math-science-technical.

Enrollment and degree data for two-year engineering technology programs offered in Florida are tabulated. In the engineering technology programs enrollments are becoming moderately large, but all of the programs are too new to have produced very many graduates. This is also true of industrial technology programs.

A large number of engineering technology and industrial technology BS degree programs have been proposed, are being planned, or are being talked about. If all of the programs under consideration in Florida were implemented in the next several years, there would be considerable duplication, and not enough students to go around.

A number of the BS technology programs in Florida are upper division programs, i.e., they start at the junior year and depend upon junior colleges to provide lower division training. This is an arrangement with which there is only limited experience and difficulties may be encountered in articulating the two parts. Florida will thus need to move slowly in such arrangements until more operating experience has been gained. The situation to be avoided is a transfer program that requires five years to obtain a degree that could be obtained in four years if these years were all spent on the same campus.

There is no four-year BS degree engineering technology program associated with a large four-year engineering program in Florida. Such a combination has many advantages, such as sharing faculty and laboratory equipment. It also provides a suitable alternative that is attractive to many students who start in engineering, but who do not persist with this subject.

Because the upper division institution will need to make remedial work available to transfer students, it is to be expected that the "upper division-only" technology program will find it necessary in most cases to provide sophomore courses in the science-technical areas of the curriculum.

<u>Chapter 7: Engineering Technology Education in Florida--Conclusions and Recommendations</u>. This is the ideal time to develop a statewide plan for BS technology education in Florida because there are enough programs to give experience on which to base planning, yet the programs already in existence do not appear to offer duplication of effort. However, if everyone who is talking about engineering technology or industrial technology starts such a program, there will almost certainly be excessive duplication, accompanied by small enrollments at individual institutions and resulting high cost.

Specific recommendations follow.

Florida A&M University. Ways should be sought to improve the academic quality, perhaps by State scholarships as well as by aggressive recruiting.

Persistence data from initial enrollment to baccalaureate degree should be obtained, and based upon these data admissions policies for engineering technology should be revised as necessary.

Present BS programs in engineering technology should be developed to ECPD-accreditation levels; additional BS degree programs should not be started until the three present programs are fully developed with adequate degree outputs and are accredited.

University of South Florida. Expansion beyond the present single option to include an additional option should be authorized as soon as present enrollment and degree output are adequate. Mechanical Engineering would be a good option to add.

After ECPD accreditation is obtained for the current option, and the enrollment and degree output of the second option are adequate, a third option may be justified.

In case the upper division plan at this institution (and elsewhere) does not prove successful, engineering technology should be restudied for the State.

Embry-Riddle Aeronautical University. The Aircraft Maintenance program at this institution is ECPD-accredited and is adequate for the entire State. It is recommended that instead of starting a duplicate program elsewhere, the State work out a funding arrangement that would provide tuition subsidy for Florida residents. This would almost certainly be less expensive to the State than a similar degree program of its own.

University of Florida. For planning purposes, the Building Construction program at the University of Florida should be considered as engineering technology. It is recommended that ECPD accreditation be sought for this program.

University of North Florida. A Construction Management program being planned at this institution should not be approved, unless the University of Florida cannot enroll all qualified Florida applicants, or unless the new program can be demonstrated to serve a really different function.

Florida Institute of Technology. The planned Air Commerce program at this institution should be encouraged and not duplicated elsewhere. A funding arrangement for Florida residents similar to that suggested above at Embry-Riddle should be developed.

University of West Florida. The proposed Systems Technology program at this institution should be given further study. In particular, before it is approved, revisions and restrictions should be imposed, as necessary, to insure that this is an engineering technology program and not a program in engineering. An engineering technology program is definitely recommended; an engineering program is not recommended.

The existing Systems Science (Scientific Option) at the University of West Florida requires modification because of the faculty viewpoint that it is an engineering program. The recommended solution is that the University of West Florida be directed (or authorized) to develop its proposed Systems Technology program and its existing Systems Science program as two options of one engineering technology program, with no engineering programs authorized at the University of West Florida.

Other Recommendations. It is recommended that one and only one four-year engineering technology program be established at a large four-year engineering college in the State. The University of Florida is the logical choice from the standpoint of enrollment of engineering students, facilities, space, and the availability of numerous faculty members who are as well or better qualified for teaching engineering technology as for teaching engineering. However, for a technology program to succeed at the University of Florida, it will be necessary to modify the present University College arrangement to permit the Engineering Technology Department to control its freshman and sophomore students.

Florida Atlantic University is interested in starting an upper division engineering technology program to serve the greater Miami area; however, it is recommended that such action be deferred for the present until there is firmer assurance that an adequate supply of students is available.

The University of West Florida has the only industrial technology program in the State; continuation of this program is recommended.

The University of North Florida is considering a BS degree program in industrial technology to start in 1973. Assuming proper planning for a quality program, approval is recommended; however, a program in engineering technology would not be recommended.

The industrial technology program under consideration by Florida International University would appear justified and should be implemented in 1974 or as soon thereafter as the initial success of the two other industrial technology programs in the State (West Florida and North Florida) can be confirmed. A program in engineering technology is not recommended.

The existing graduate-level program in Aeronautical Systems at the University of West Florida is probably the first master's program in engineering technology in the nation. It is recommended that this program be labeled as engineering technology, and that the possibility of ECPD accrediting be explored.

Chapter 1

ENGINEERING EDUCATION IN THE UNITED STATES

The national view of engineering education given in this Chapter provides a background against which to consider engineering education in Florida.

1.1 Bachelor's Degrees Awarded in Engineering in the United States. The number of bachelor's degrees awarded in engineering in the United States since 1956 is given in Fig. 1-1. During the decade of the sixties, the number of such degrees was roughly constant, but with a slight rising trend during the last half of the period. However, when these BS engineers are expressed as a percentage of all men receiving the baccalaureate degree, the engineers represent a slowly declining percentage of the male baccalaureate population.

Experience over the years has shown that the number of engineers graduating from college is determined by the values and aspirations of young people. This number is largely independent of the needs of our society for college graduates with engineering training. In this connection it is to be noted that engineering has very little appeal for women in the US, although other countries, notably the USSR, enroll many women as engineering students.

1.2 Master's Degrees. The master's degree (MS, ME) has come to be regarded as the preferred level of training for the general practice of professional engineering. At an earlier time, the bachelor's degree served this function. However, with the growing technological complexity of our society, a four-year education, however good, is now inadequate to enable an engineer either to come to grips with the more interesting and challenging contemporary problems, or to provide a satisfactory background for learning the new things that continue to come along in engineering.

As a consequence, the number of master's degrees awarded has increased rapidly in recent years as shown in Fig. 1-2, and by 1968 was

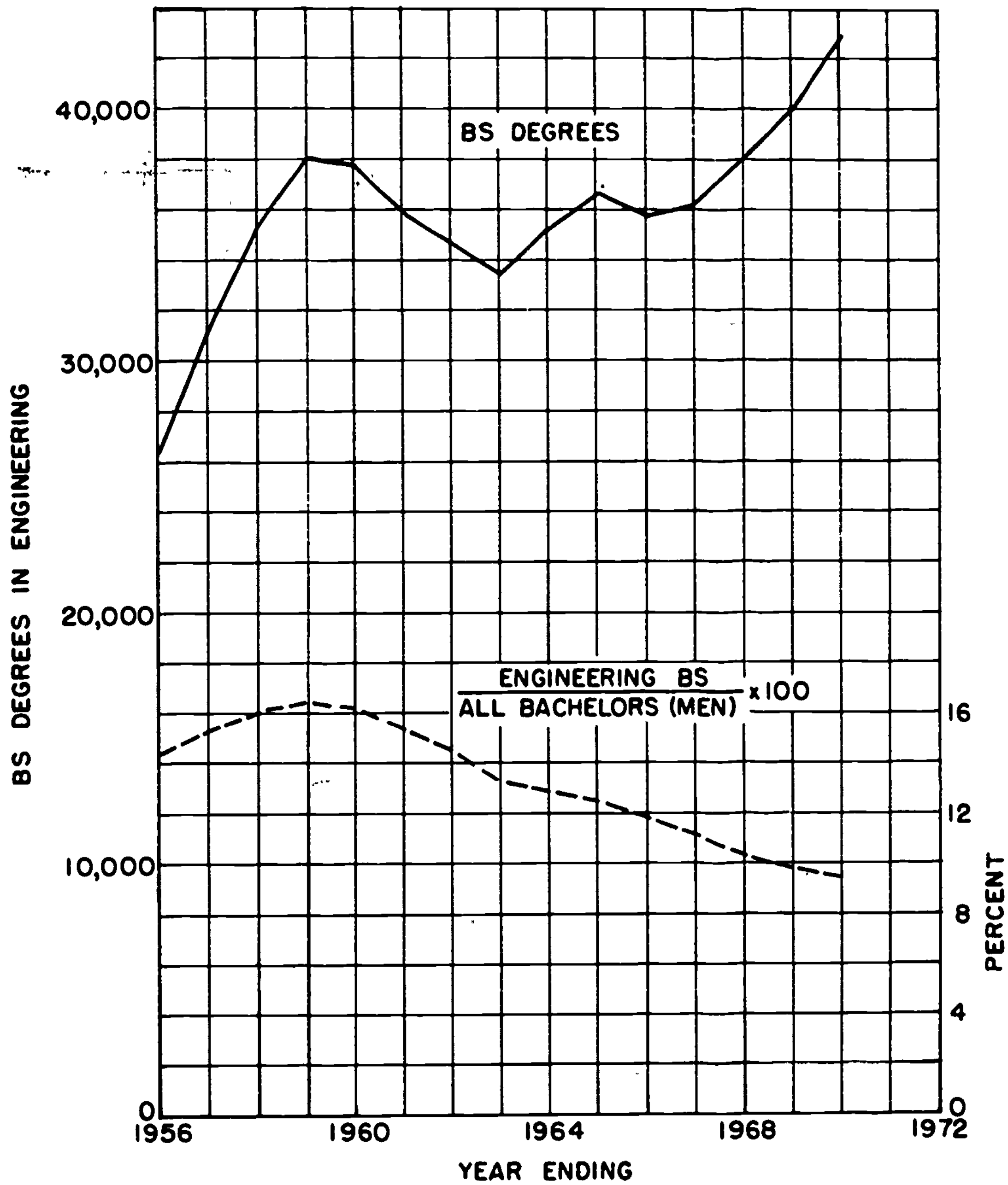

Fig. 1-1. BS degrees awarded in engineering in entire United States.

(Sources: Engineering Degrees, USOE, EMC)

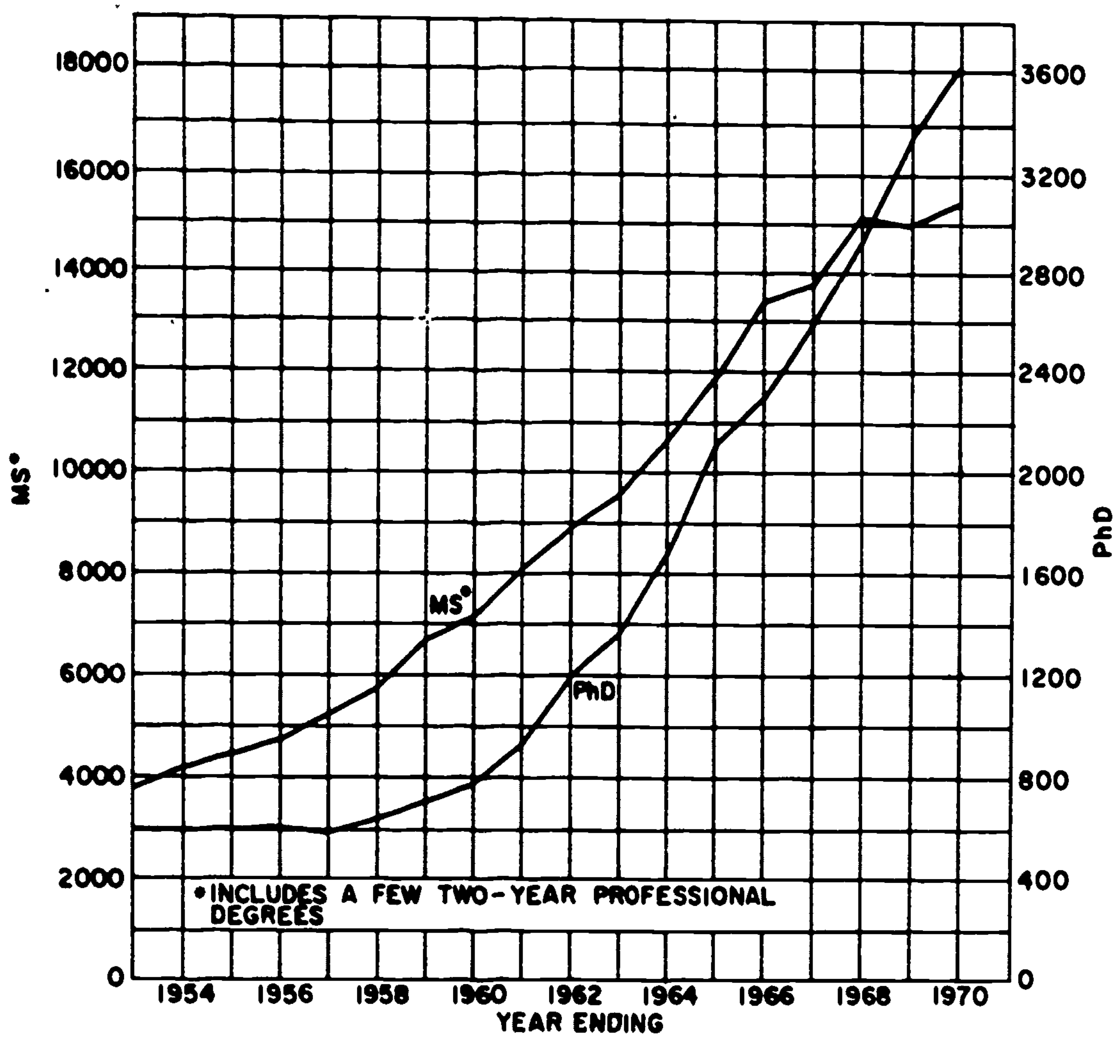

Fig. 1-2. Output of advanced degrees in engineering in entire United States.

(Sources: Engineering Degrees, USOE, EMC)

about 40% of the number of bachelor's degrees awarded two years earlier. In addition, others do graduate work without completing all of the requirements for advanced degrees. This situation is to be compared with 1953, when the master's output was approximately 10% of the BS class of 1951.

1.3 Doctoral Study. The doctorate in engineering (PhD, ScD, and D. Eng) has assumed the role that twenty years ago was supplied by the master's degree. The doctorate in engineering is now the normal training for those who desire to follow a career in teaching, or in fundamental research or advanced development. It is also sought by those looking forward to a career in engineering practice who desire a stronger technical background than is represented by the one year of graduate study required to obtain a master's degree. As Fig. 1-2 shows, a steadily growing number of engineers are now continuing their studies to the doctorate; in 1968-69 and again in 1969-70 the number of doctor's degrees awarded was approximately 10% of the BS degrees awarded six years earlier.

The dramatic changes that have taken place in engineering in the last fifteen years are indicated by the fact that in 1951 approximately 10% of those graduating in engineering pursued their studies to the master's level, whereas this same percentage of those graduating in 1963 carried their studies to the doctoral level. The young engineers of today are on the average far better educated than were their predecessors of 15-20 years ago.

There are indications that a new trend is developing in the doctoral training of engineers. In the past fifteen years the growing supply of doctorates in engineering has gone largely into teaching and/or research and advanced development. However, during the 1970's neither of these job markets will be requiring new doctorates in anything like the numbers absorbed in the past decade. On the other hand, there will be an increasing demand for engineers trained beyond the master's degree and qualified for the general practice of engineering at the very highest level. The proper training for such a career should be equivalent to that of the traditional research doctorate as far as intellectual standards are concerned, but should place greater emphasis on breadth of training, and on the practice of engineering as distinct from research. The relation existing between the MD and the PhD degrees awarded in medicine represents an analogous situation. In some institutions, this change in viewpoint is being introduced under the umbrella of the traditional PhD; in other cases, the degree Doctor of Engineering is used as the vehicle.

1.4 Distribution of Engineering Degrees by Field. The distribution of 1969-70 BS graduates in engineering by field is given in Fig. 1-3.

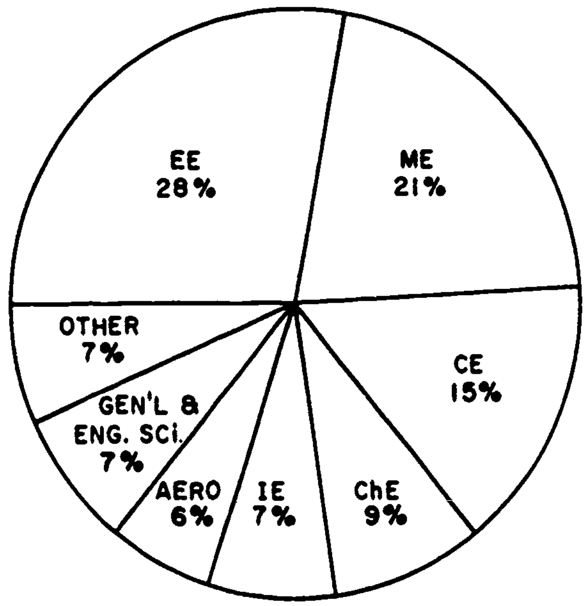

Fig. 1-3 Distribution of bachelor's degrees by field of engineering.

(Source: Engineering Degrees 1969-70, Engineering Manpower Commission)

The six most popular fields (electrical, mechanical, civil, chemical, industrial, and aeronautical, in that order) accounted for 86% of all bachelor's degrees in engineering in 1969-70. An additional 7% graduated in engineering without designating a field (general engineering and engineering science). The remaining several dozen fields of engineering between them accounted for only 7% of the baccalaureate output. Thus, as far as undergraduate education is concerned, engineering consists of a few mainstreams supplemented by a substantial number of tiny rivulets.[1]

The distribution of advanced degrees by field is similar, except that a slightly higher proportion of the degrees are in the "Engineering Science" and "Other" categories.

1.5 Current Enrollment Trends. An examination of enrollments gives a clue to changes that are currently taking place in engineering. Enrollment data for the last four years are given in Table 1-1.

At undergraduate level, it is seen that with the graduation in 1970 of the seniors of the fall of 1969, the next several graduating classes will be slightly smaller; thus, the 42,966 bachelor's degrees awarded in 1969-70 (see Fig. 1-1) will probably represent a small peak.

At the master's degree level, significant changes have already taken place. The rapid increase in degrees awarded leveled off in 1968-69 as a result of changes in Selective Service policies. It is unlikely that the earlier trend will be resumed; rather the most reasonable expectation is that the decade of the seventies will show a slow rise in the number of master's degrees awarded, until the number becomes 50-60% of the BS production. This future leveling off is inevitable, because not every BS graduate is either qualified or desirous of becoming a professional engineer at a relatively high technological level.

As for doctoral degrees, either a leveling off or a modest reduction in the doctoral output of engineers can be expected in the 1970's. In the seventies, universities, defense industries, and the space program

[1]It is argued by some that the tiny rivulets of today are very important because they will become the raging streams of tomorrow. However, past history and present trends do not support this view. The mainstream fields of electrical, mechanical and civil engineering are broad and flexible, and continue to include the main body of technological knowledge as they evolve. They were dominant fifty years ago, and are still dominant today, because the distribution of emphasis within each individual field has changed with time--e.g., electrical power vs. electronics. The prediction is that these same mainstream fields will continue to be dominant tomorrow and also the day after tomorrow.

Table 1-1

U. S. ENGINEERING ENROLLMENTS FALL 1967-1970

	Enrollments			
	Fall 1967	Fall 1968	Fall 1969	Fall 1970*
Freshman Full-time	77,551	77,484	74,080	73,950
Sophomore Full-time	56,975	55,615	53,240	52,800
Junior Full-time	50,483	50,274	49,910	48,900
Senior Full-time	47,551	50,736	51,270	50,100
Fifth Year Full-time	4,589	5,133	4,670	4,550
Total Full-time Undergrad.	237,149	239,242	233,170	230,300
Part-time Undergrad.	NA	20,940	22,060	21,056
Master's Candidates Full-time	34,231	24,469	20,070	22,950
Doctor's Candidates Full-time	15,376	15,768	14,400	14,300
Total Full-time Graduate	49,607	40,237	34,470	37,250
Master's Candidates Part-time	NA	22,883	27,080	25,050
Doctor's Candidates Part-time	NA	4,163	5,600	4,650
Total Part-time Graduate	NA	27,046	32,680	29,700
Total Master's Candidates [PT+FT]	NA	47,353	47,150	48,000
Total Graduate Students [PT+FT]	NA	67,283	67,150	66,950

*Approximate

Source: Engineering Manpower Commission.

will no longer require an ever-growing number of engineers with doctoral training; in addition, government support of doctoral students in the form of traineeships and fellowships is being phased out. At the same time, the number of doctoral students in engineering will continue at a relatively high level.

1.6 Patterns of Graduate Education. Most graduate students in engineering require some form of financial assistance. As a consequence, a number of patterns of graduate education in engineering have developed. The two most important of these are: (*a*) full-time-on-campus students, and (*b*) part-time-on-campus industrial students.

The full-time-on-campus graduate student spends essentially full time on campus, and the principal focus of his life is related to campus activities. He is either a full-time student, ordinarily supported by a fellowship, a traineeship, or a working wife; or he works part-time on the campus, typically as a Research or Teaching Assistant, and is generally enrolled on a not-less-than-half-time basis.[1]

The part-time industrial graduate student holds a full-time or nearly full-time position as an engineer in an industrial concern. Typically he enrolls for a less-than-half-time program of study--usually in evening or late afternoon courses but sometimes as a part-time day student. The part-time industrial student is characterized by having a primary responsibility to an off-campus employer.

Doctoral programs in engineering are ordinarily built around the full-time-on-campus student. The length of the doctoral program and the concentration required during the research phase militate against the

[1]Relatively few full-time-on-campus engineering students are supported by parents or equivalent sources. This fact often surprises nonacademic people, but it is an elementary principle of academic life known to every engineering dean and department head who has succeeded in building up a substantial group of full-time-on-campus engineering students. The reason appears to be that in spite of our affluent society, the mores of young people today are such that most of those who might get full parental help prefer to provide a substantial part or all of their support through their own efforts, and do not enroll as full-time graduate engineering students if self-support is not possible.

student whose main responsibility is to an off-campus employer. The part-time master's program is found in practice to be a rather poor feeder for the doctoral program, compared with the full-time-on-campus student group. Thus may, however, become less true as Doctor of Engineering programs gain in popularity.

1.7 Part-time Graduate Study. Over one-half of the engineers enrolled for the master's degree, and a smaller fraction of those working for the doctorate, are part-time students who have full-time or nearly full-time employment in industry. The pertinent data on such study during the last several years are given in Table 1-1.

The availability of appropriate part-time graduate programs is very important to industrial firms using advanced technologies. Such programs aid in the recruiting of able and ambitious young engineers with BS degrees who desire more education but who also have financial needs that make immediate employment necessary. These programs also provide means of upgrading the knowledge and hence the value of employees. As a result, industrial firms located in areas where quality part-time degree programs are available are able to recruit a better grade of personnel and thus obtain an edge over less favorably situated competitors. Because of this, progressive firms tend to be located where quality graduate work is available, and then encourage part-time graduate study through such devices as rebating tuition and fees, giving released time where necessary, aiding schools by making available experienced engineers as lecturers, etc.

As financial support for full-time graduate students becomes ever tighter, and as technological aids for graduate education become more widely used (see Chapter 3), the availability of high quality graduate programs for part-time study will become steadily more important to the industrial development of a region or a state.

1.8 The Undergraduate-only Engineering School Is Disappearing. As the master's degree becomes more and more accepted as the appropriate preparation for full professional status in engineering, the engineering school that offers no engineering beyond the bachelor's level is at a growing disadvantage. Such an institution will find it more and more difficult to recruit and to hold a competent faculty; as a consequence it will be progressively less attractive to students as a place to study engineering. Thus, a decision to initiate an undergraduate engineering program on a campus is for all practical purposes also a commitment to start a master's program at an early date. This is attested to by the fact that of the 194 institutions with one or more accredited BS engineering programs in 1969-70, 173 awarded a master's degree in at least one field.

1.9 Economics of Engineering Education. The economics of engineering education are important because engineering is generally considered to be expensive education. However, this high cost is more apparent than real if one allows for the fact that engineering courses are concentrated largely at upper division and graduate levels and involve a substantial amount of laboratory activity. In actual fact, engineering is typically no more expensive than upper division and graduate physics, chemistry, or biology.

It has been shown that in a BS engineering program, there is a minimum desirable size which is 40-50 BS degrees per year produced by each independent curriculum, corresponding to 140-150 BS degrees per year in a an undergraduate program having three or four independent curricula.[1] When a department of an engineering school is appreciably below this desirable size, the instruction cost per student credit hour increases as a result of too many classes having low enrollments.

At master's level the same criteria apply; if the number of master's degrees awarded annually in each independent curriculum falls below 40-50, then instruction costs rise without any corresponding benefit in quality. If the master's degree is given without thesis, and an adequate supply of students is available, the master's program should be no more expensive to

[1]F. E. Terman, "Economic Factors Relating to Engineering Programs," Journal of Engineering Education, Vol. 59, pp. 510-514, February 1969. The applicable sections of this article are reprinted in Appendix A.

teach than the undergraduate engineering program, assuming there is not an invidious difference in the quality of the instructors teaching the undergraduate and graduate parts of the curriculum.

Doctoral programs are generally considered to be very expensive, but this view needs to be qualified in engineering. Specifically, if a doctoral program exists in association with a strong MS program possessing considerable diversity, it is normally not necessary to add any courses specifically for doctoral students outside of seminars and an occasional specialty course. Thus, the presence of a doctoral program does not adversely affect the economics of classroom teaching; on the contrary, it should help swell the ranks of the master's level classes. At the same time, the rather expensive research activities carried on by doctoral students in cooperation with their faculty supervisors are commonly financed in large part by government contracts and grants, and thus do not necessarily put a strain on the finances of the institution.

The view that graduate work need not be expensive, provided there is an adequate graduate student population and that adequate research grants and contracts are available, is confirmed by instructional cost data on prestigious institutions with very large master's and doctoral activities; institutions such as MIT, Stanford, and Illinois that have high quality faculty and very large graduate programs operate with instruction costs per student credit hour that are in the middle range for engineering schools in general.

A survey shows that approximately fifty per cent of the institutions now offering a bachelor's degree in engineering are underpopulated with students to the point where they cannot make efficient use of the available faculty teaching effort. Similarly, only about twenty per cent of the schools now offering master's degrees have a sufficient number of MS students to achieve the minimum size required for economic operation.[1]

[1] Ibid.

1.10 Single Undergraduate Curriculum vs. Multiple Undergraduate Curricula in Engineering. At the undergraduate level, many entering freshmen headed toward engineering have not yet decided which field of engineering they prefer. Others who indicate an initial preference often change fields by the time they are halfway toward graduation. It is therefore desirable that undergraduate engineering students have an opportunity to examine different fields while in college. This means that to meet simultaneously (*a*) the diverse and evolving needs of engineering students, and (*b*) the criteria for economic operation (see Sec. 1.9), there should be 3 to 5 mainstream curricula available, corresponding to at least 125 to 150 BS degrees per year.

When the number of students is substantially less, as is inevitably the case in newly established engineering schools, a practical way to handle the situation is to start with a single undergraduate curriculum in General Engineering[1] which provides some, but only limited, opportunity to specialize in a particular field. As the enrollment builds up, conventional majors in individual mainstream fields can then be spun off as the number of students interested in a particular field becomes large enough to justify a separate curriculum, while still using the General Engineering umbrella to serve the remaining students.

"Stand-alone" Engineering Specialties. When an institution is establishing an undergraduate engineering program, there is a temptation to consider the possibility of concentrating instruction in some particular field, such as Ocean Engineering, Environmental Engineering, or true Engineering Science. Such specialization does not generally work out, however, since as already noted, high school graduates headed toward engineering typically have not firmly decided on a particular field of

[1]In some cases, the name "Engineering Science" is associated with such programs in General Engineering. In this connection, a distinction must be made between the so-called "Engineering Science" program that emphasizes basic or general engineering, and a true Engineering Science program in which advanced courses in science or applied science replace the usual departmental major subjects.

engineering at the time they enter college. Under these circumstances, an institution that offers no alternatives to a single highly specialized curriculum has limited appeal. A further factor working against a "stand-alone" specialty is that it is generally a unique specialty, such as Ceramic Engineering, Ocean Engineering, or Engineering Science, rather than a mainstream field such as Electrical Engineering; this means that the "stand-alone" curriculum is necessarily one of the tiny rivulets of engineering referred to in connection with Fig. 1-3, and so is of interest to only a very small fraction of those studying engineering.

The best home for a narrow undergraduate specialty is in an institution having a large undergraduate enrollment; in this way even if only a small percentage of the undergraduate students are interested in that unique area of engineering, the numbers still are respectable because of the large base.

In an upper division university, the situation is tempered somewhat because the students are more mature. On the other hand, the same problems exist, though to a lesser extent. This is because students in junior colleges get only a very limited exposure to engineering subjects and thus do not necessarily arrive at firm decisions about their relative interest in particular fields of engineering.

Specialization at Graduate Level. In graduate programs, the basic considerations are different. Graduate student .e already selected a specialty because of their undergraduate experience. Hence, a graduate school can offer a rather narrow specialty, and then recruit students for its full-time-on-campus program who have this particular interest, drawing these students from the entire State, or region, or even country. The number of students that can be obtained for a particular specialty will then depend primarily on the support funds available, and the attractiveness (i.e., quality) of the program.

1.11 <u>Proliferation of Departments and of Course Offerings</u>. As the number of engineering students at a given institution increases there is a characteristic tendency to neutralize the benefits of large-scale operation by forming new departments and by allowing these departments to sponsor overlapping courses.

The proliferation of degree-granting curricula and academic departments encourages over-narrow specialization in course offerings, and at the same time tends to raise instruction cost by distributing a limited pool of students over an unnecessarily large number of curricula. While campuses having large undergraduate engineering enrollments can support a limited number of majors in the "rivulet" category, there is a tendency to carry this proliferation to the point where: (a) the numbers in some of the mainstream fields have been depleted below desirable levels, and (b) the total effort being devoted to the engineering fields of secondary importance is disproportionately large. In many situations, a narrow specialty can be adequately handled by treating it is a limited option within a broader curriculum, rather than by setting up an independent department to serve this interest.[1]

Course Duplication. When there are many undergraduate engineering curricula, there is a strong tendency for independent and overlapping introductory courses in fluid mechanics to exist in the Civil Engineering, Mechanical Engineering, Aeronautical Engineering, Ocean Engineering, Nuclear Engineering, Chemical Engineering, etc., departments, whereas a single carefully planned basic course would serve these various interests equally well, if not better. A single course would also make it clear to the students (and to the faculty) that the basic principles of fluid mechanics are the same irrespective of the application. The same situation tends to exist in the areas of solid mechanics, control systems, computer applications, thermodynamics and materials (metallurgy).

While vested and parochial interests often make it difficult to effect a desirable consolidation, the advantages of doing so are numerous. When one basic course with a substantial enrollment replaces a number of

[1] To put this matter into perspective, it is to be recalled that Fig. 1-3 shows that 64% of all engineering bachelor's degrees awarded in the US are in three fields, while 93% are in six independent fields (plus undifferentiated General Engineering and Engineering Science majors).

overlapping courses, each tailored to an imagined special interest, and each with a small enrollment, it is possible to put more effort into planning and teaching the one course, and to assign to it the faculty member(s) best suited for the course. This saves money, improves the quality of instruction, and as a by-product adds a needed element of unity to the engineering curricula.

1.12 Measures of Faculty Productivity and Activity. The burden represented by the teaching activities of a faculty member is commonly expressed in terms of teaching load, i.e., the number of classes met per week, or the number of contact hours per week. However, the useful output that results from this effort is measured in terms of student credit hours awarded to those enrolled in the classes constituting the faculty member's teaching load. This productivity depends as much upon average class size as upon teaching load, and tends to be low when classes are small, i.e., when there is an insufficient supply of students, or if there is an unnecessary proliferation of course offerings. It is possible to maintain a relatively high productivity with light-to-moderate teaching loads by giving professors the opportunity to appear before an adequate number of students in each class.

Faculty productivity in PhD work is measured in terms of PhD's per faculty member per year. A faculty member with superior research qualifications whose research is adequately funded can on the average produce about one PhD per year. Engineering schools with high faculty standards and adequate research support will typically produce 0.5 or more PhD's per faculty member per year, including assistant professors in the base but excluding lecturers, visitors, and instructors.

1.13 Master's Degree Policies. Engineering schools that are interested in academic excellence and that have active doctoral programs involving a substantial fraction of the faculty commonly award the master's degree on the basis of course work alone, and concentrate student-faculty research at the doctoral level. This arrangement makes more faculty time available for the supervision of really meaningful research, thereby raising the quality of faculty research and of the campus activities. In contrast, master's level research consumes a substantial amount of faculty effort, yet because of the limited time available to the student does not ordinarily produce results which add materially to the experience of the faculty supervisor or to the reputation of the institution. To the student, MS thesis research represents a useful experience having an educational value comparable with but not necessarily superior to the additional graduate courses that the thesis replaces.

Institutions that do not offer the doctorate in engineering, on the other hand, do normally require a master's thesis. This is because it is desirable from an educational point of view that there be some research taking place on the campus. Also it is good for the faculty to work with students on research; in the absence of doctoral students, master's level research is far preferable to no student-faculty research at all. Part-time students who are employed in industry can, however, be appropriately exempted from submitting a master's thesis even under such circumstances. These students are already gaining experience with the real world of engineering through their employment, and so find a master's thesis of less educational value than do students without industrial experience. At the same time, extra course work is generally of proportionately greater value to the part-time industrial student.

1.14 <u>The Supply and Demand for Engineers</u>. The nation's supply of engineers is represented by those individuals receiving the BS degree in engineering. Students awarded the master's and doctor's degrees in engineering do not add to the supply since with only small adjustments they are included in those who received BS degrees. This means that in the decade looking ahead there will be approximately as many engineers produced as were produced during the past decade. While a concern has been expressed that as our society becomes increasingly technology-oriented, there will be a shortage of engineers, it is believed that the expected output will take care of the needs. This is because of the high level of training which engineers now obtain, and because Bachelor of Engineering Technology and similar programs provide increasing support for the engineering profession.

The demand for engineers at bachelor's and master's levels varies with the economic cycle. Past experience is that engineers with this level of education can always find jobs, although when jobs are scarce, the individual may have to hunt for his first position and then often accept what is available. Even in the present tight job market, young engineers are finding positions at salaries that are the same or a little higher than a year ago, namely of the order of $10,000/year.

The situation with men receiving the doctorate has been changing in the last several years. Individuals with doctoral training have in the past customarily gone into teaching or into specialized research and development. However, it is clear that in the 1970's there will be fewer new academic positions to be filled than during the 1960's. Concurrently, the space program is slowing down; defense expenditures for research and development are not expanding as in the past; and research activities in new areas related to environment, urban problems, transportation, etc., are growing only very slowly.[1] As a consequence, the demand for new engineering PhD's for R&D positions has softened.

While the country in general, and industry in particular, will continue to need a steady input of engineers who are trained beyond a master's degree, this need will be more in connection with general engineering practice than with teaching or with research and development. In the future, the training of doctoral students should accordingly give increased attention to breadth of training as against depth in a narrow research specialty, and should emphasize the practice of engineering more

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[1] A recent statement by Dr. Lester C. Thurow of MIT's Economics Department gives perspective on this situation. In Technology Review, June 1971, he says:

> The typical goal of high technology is to do something that has never been done before. But when we come to attacking the problems on which Americans are now putting highest priority, we tend to give a different emphasis. We simply want to do more of what we've already done before, and do it cheaper. If defense problems require "high" technology, today's civilian problems tend to require "low" technology.

than has been the case with the traditional research-oriented engineering doctoral program. As noted in Sec. 1.3, a trend in this direction is already becoming visible.

The present unemployment problems in engineering are concentrated primarily in the aerospace field, and largely affect those who have had a number of years experience in a highly specialized technology. Such individuals are not readily convertible to other fields of activity, being often less well qualified for other activities than are younger men with more modern training. This poses a difficult problem--one for which there is no easy solution. However, in spite of the plight of these older specialists, well-trained young engineers coming out of college have a promising future ahead of them, and engineers who are employed will always benefit by part-time study that improves their competence.

1.15 Engineering Education and Economic Growth. Since World War II, this country has witnessed an unprecedented expansion of industries based on sophisticated applications of science and technology. Examples include electronics, instrumentation, computers, communication, automation, navigation, aerospace, etc., etc. These are often called "growth" industries because so many companies of this type have had remarkable growth records during the last twenty years. A few of the more spectacular examples are IBM, Xerox, Polaroid, and Hewlett-Packard; however, there are literally thousands of companies of this type that have established a place for themselves in the US economy since World War II.

These technology-oriented growth companies are very attractive to communities desiring to strengthen their economic bases. They are non-polluting. Their employees have a high average level of education and skills and thus tend to be in higher-than-average income brackets. Moreover, these employees typically have a strong interest in education, good government, etc. Except for aerospace, the employment in these growth industries tends to be relatively stable.

The basic characteristic which growth companies share in common is that their growth arises from the creation of new products. They depend upon advances in technology, and they live very close to the frontiers of knowledge. The market-place success of concerns of this type, and even their continued existence in a competitive economy, is accordingly strongly dependent upon the quality of the engineering personnel and the extent to which these individuals keep up with a rapidly changing technology.

Education is therefore an all-important component of raw material to growth companies. When attractive opportunities are available for part-time education and for the continuous updating of knowledge, it is possible for a firm to recruit higher quality employees and to maintain them at a high level of effectiveness. However, educational opportunities are attractive <u>only if they are of high quality and are conveniently available</u>. Second-class quality will attract and hold only second-class people. Likewise, part-time study achieved only through great personal sacrifice and/or disruption of family life is a strong negative factor compared with employment in geographical areas elsewhere that do not share these disadvantages.

Chapter 2

ENGINEERING EDUCATION IN FLORIDA

Engineering education in Florida has in recent years been strongly influenced by rapid expansion of higher education generally, by a rapid growth of population, and by an impressive industrial development that has emphasized advanced technology (electronics, computers, instrumentation, control systems, aerospace, communications, etc.). Engineering has been introduced on new campuses; increased attention has been given to graduate work; and innovations have been introduced to make graduate degree programs in engineering available to industrial employees.

2.1 Engineering Bachelor's Degree Output in Florida. The number of bachelor's degrees awarded in Florida in engineering is given in Fig. 2-1,[1] and follows the general trend of the US output (see Fig. 1-1) after allowance is made for the rapid population growth of Florida. However, as noted in Fig. 2-1, Florida produces a substantially smaller fraction of the country's BS engineers than its proportionate share based on population.

2.2 Graduate Degrees in Engineering. The numbers of master's and doctor's degrees awarded in engineering by Florida institutions are given in Figs. 2-2 and 2-3, respectively. It is to be noted that as in the case of BS degrees, Florida produces fewer of the nation's engineering master's and doctoral degrees than its proportional share on a population basis.

2.3 Distribution of Degrees among Schools. A chronological tabulation of engineering degrees awarded by individual institutions is given in Table 2-1. This reveals several significant features. Until 1959-60, only two Florida institutions, one public (University of Florida) and one

[1] All graphs and tables of degrees awarded in Florida are for the year ending June 30, in order to conform with US Office of Education data.

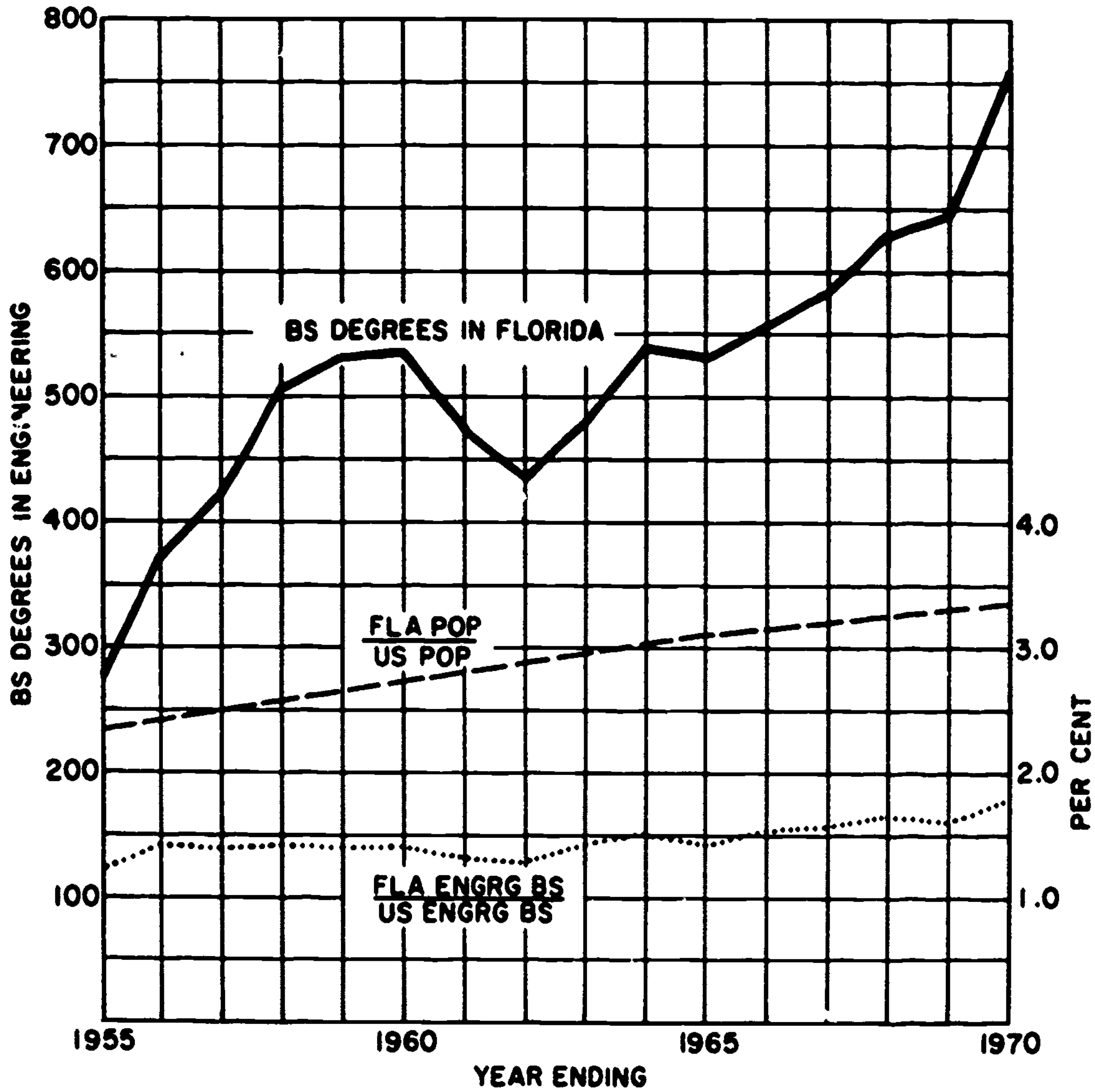

Fig. 2-1. BS engineering degrees awarded by Florida institutions.

(Sources: Engineering Degrees, USOE, EMC)

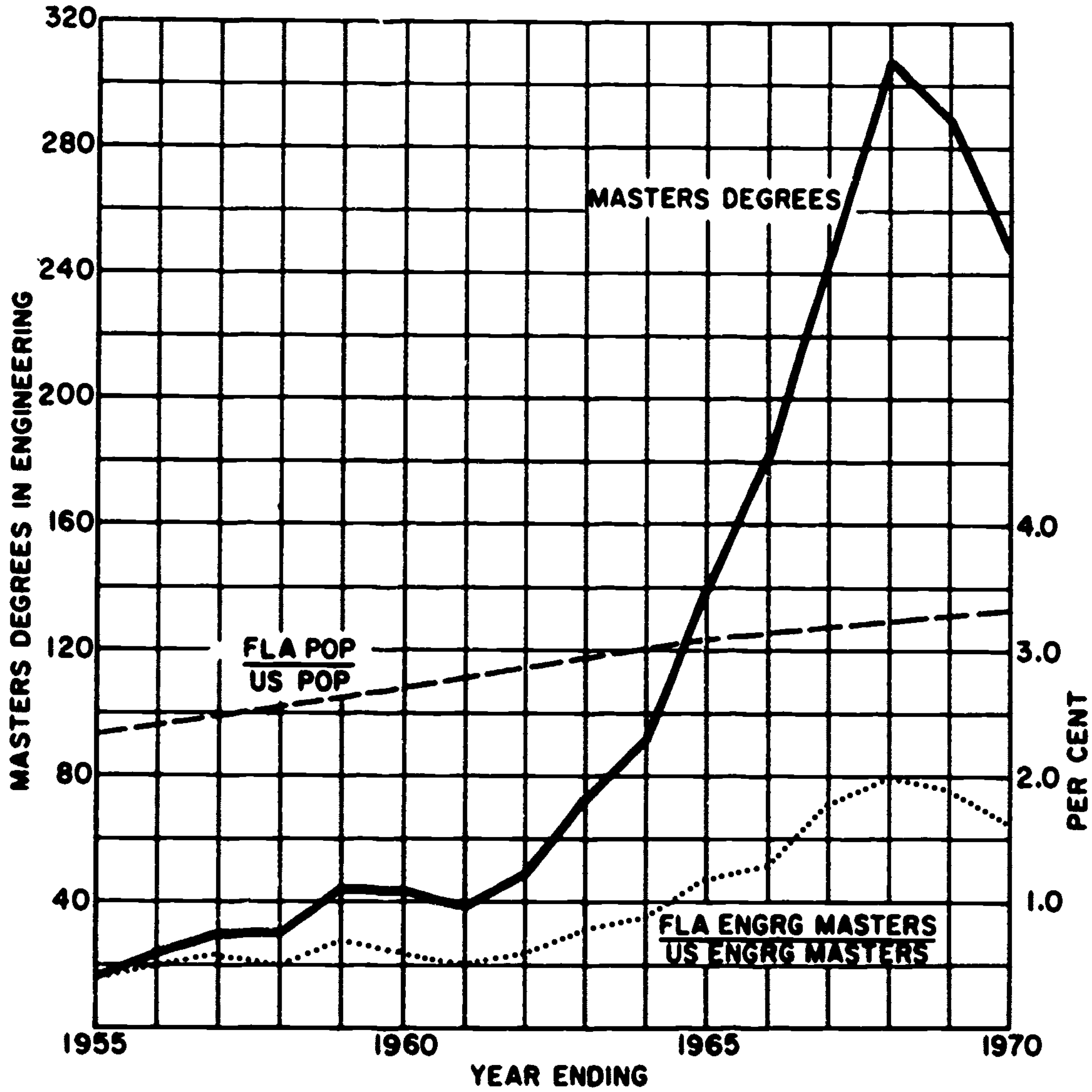

Fig. 2-2. Master's degrees in engineering awarded by Florida institutions.

(Sources: Engineering Degrees, USOE, EMC)

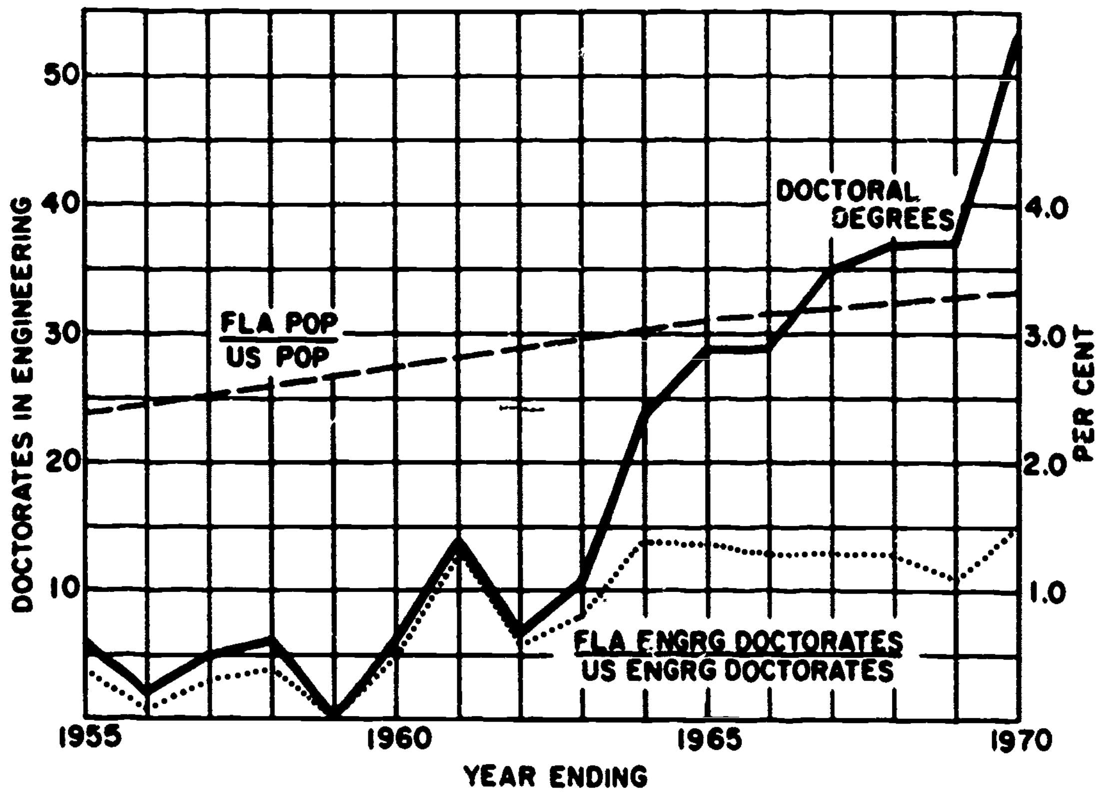

Fig. 2-3. Doctoral degrees in engineering awarded by Florida institutions.

(Sources: Engineering Degrees, USOE, EMC)

private (University of Miami) had ever awarded a BS degree in engineering. Today, there are five public and three private institutions awarding the BS degree.

In spite of this expansion in the number of institutions offering engineering, Florida's proportional share of the national output has not increased. Also, the University of Florida still produces over 50% of all bachelor's degrees awarded in the State.

At graduate level, the University of Florida is the only institution in the State that awarded master's degrees in engineering before 1962-63, and it still accounts for about 60% of all engineering master's degrees awarded in Florida, even though in 1969-70 five schools offered instruction at this level (three public, two private).

Table 2-1

CHRONOLOGICAL HISTORY OF DEGREES AWARDED IN ENGINEERING IN INDIVIDUAL FLORIDA INSTITUTIONS

Year	Emb. Rid.	Fla. IT	Miami	Fla. Atl.	Fla. St.	Fla. TU	So. Fla.	U.of Fla.	(Gen.)*	Total Fla.	Total U.S.	Fla./U.S. %
					Bachelor's Degrees in Engineering							
1955-56			113					260		373	26,306	1.4%
1956-57			140					283		423	31,211	1.4
1957-58			139					367		506	35,332	1.4
1958-59			162					371		533	38,134	1.4
1959-60			172		2			362		536	37,808	1.4
1960-61			110		4			360		474	35,860	1.3
1961-62			139		5			293		437	34,735	1.3
1962-63	28		111		2			340		481	33,458	1.4
1963-64	33		116		9			382		540	35,226	1.5
1964-65	61	20	79		12			359		531	36,691	1.5
1965-66	33	25	91		12			396		557	35,815	1.6
1966-67	23	40	73	10	20		31	387		584	36,186	1.6
1967-68	15	41	83	19	21		42	409		630	38,002	1.7
1968-69	35	54	89	31	25		79	331		644	39,972	1.6
1969-70	34	49	122	25	3	3	96	391		759	42,966	1.8
					Master's Degrees in Engineering							
1955-56								24		24	4,724	.5%
1956-57								30		30	5,232	.6
1957-58								30		30	5,788	.5
1958-59								44		44	6,753	.7
1959-60								43		43	7,159	.6
1960-61								39		39	8,177	.5
1961-62								49		49	8,909	.6
1962-63					3			71		74	9,635	.8
1963-64					4			89		93	10,827	.9
1964-65		7	5		6			123	(8)	141	12,056	1.2
1965-66		18	8		7			149	(36)	182	13,677	1.3
1966-67		36	17		13		6	172	(46)	246b	13,887	1.8
1967-68		44	29		11		38	186	(37)	308	15,152	2.0
1968-69		34	26		10		32	187	(29)	289	14,938	1.9
1969-70		26	22	a	12	a	37	148	(34)	245	15,548	1.6

* Degrees in parentheses are Genesys degrees and are included in University of Florida totals.
a Master'[illegible] [illegible]rized.
b Inclu[illegible] [illegible] Rollins College.

Year	Emb. Rid.	Fla. IT	Miami	Fla. Atl.	Fla. St.	Fla. TU	So. Fla.	U.of Fla.	(Gen.)*	Total Fla.	Total U.S.	Fla./U.S. %
					Doctorates in Engineering							
1955-56								1		1	610	[illegible]
1956-57								3		3	596	.5
1957-58								4		4	647	.6
1958-59								-		-	714	.0
1959-60								5		5	786	.6
1960-61								13		13	943	1.4
1961-62								7		7	1,207	.6
1962-63								11		11	1,378	.8
1963-64								24		24	1,693	1.4
1964-65								29		29	2,124	1.4
1965-66								29		29	2,303	1.3
1966-67								35		35	2,614	1.3
1967-68								37		37	2,933	1.3
1968-69								37		37	3,387	1.1
1969-70			1					52		53	3,620	1.5

Sources: Engineering Degrees and Enrollments, USOE, EMC.

All engineering doctorates awarded in Florida to date have been produced by the University of Florida with only the merest exception.[1]

2.4 Distribution of Engineering Degrees among Fields of Engineering. Table 2-2 shows the distribution by field of the engineering degrees awarded by Florida institutions in 1969-70. The breadth of coverage is more than adequate to meet the needs of the students and of the State.

When the number of degrees awarded in each curriculum at bachelor's and master's levels is examined in relation to the criteria for minimum economic size (see Sec. 1.9), it will be found that many of the BS curricula are well below the 40-50 BS degrees/year criterion. Only a few of the master's programs approach the minimum size required for economical operation, and most are substantially below. It is clear that with more engineering students at undergraduate and graduate levels, the instruction costs per student at all of the Florida institutions would be lowered. Stated in another way, Florida has more engineering schools than it needs.[2]

Emphasis on the Ocean. Many engineering programs in Florida place strong emphasis on the ocean, as might be expected. However, this has now reached the point where one can raise the question of whether or not there is an overemphasis on the subject.[3] Thus the University of Florida has a separate department of Coastal and Oceanographic Engineering that offers an MS degree.[4] Florida Atlantic offers BS and MS programs in Ocean Engineering; while the University of Miami offers an MS degree in Ocean Engineering, together with Ocean Engineering options in the undergraduate curricula of CE, EE, IE and ME. In addition, various

[1] In 1969-70, University of Miami awarded one doctorate in engineering and predicts an additional one in 1971.

[2] The decision to phase out engineering at Florida State University (see p. 81) is a help in this connection.

[3] The possibility of overemphasis is quite real; thus the American Geological Institute study, Manpower Supply and Demand in the Earth Sciences, 1971, says: "Enrollment in oceanography curriculum should be reviewed carefully as job opportunities appear to be limited."

[4] A PhD is also available in this field as an option within Civil Engineering.

Table 2-2

ENGINEERING DEGREES BY FIELD

FLORIDA 1969-70

	Aero	ChE	CE	EE	Eng Sci	Genl.	IE& Mgmt	ME	Mat& Met	Other	Total
Bachelor's Degrees:											
Univ. Florida	39	29	34	133	13[i]		66[g]	47	7	23[b]	391
Florida Atl.				[a]				[a]		25[c]	25
Florida St.					39						39
Fla. Tech. U.				1				2			3
So. Florida						96					96
Embry-Riddle	34										34
Fla. Inst. T.				49							49
Miami, U. of			25	50			13	29		5[d]	122
Total	73	29	59	233	52	96	79	78	7	53	759
Master's Degrees:											
Univ. Florida	2	10	24[h]	22	3[i]		23	13	7	10[e]	114
GENESYS	1			19	3[i]		5	6			34
Florida St.					12						12
So. Florida						37					37
Fla. Inst. T.				26							26
Miami, U. of			7	5			2	8			22
Total	3	10	31	72	18	37	30	27	7	10	245
Doctor's Degrees:											
Univ. Florida	4	3	7[h]	11	3[i]		7	5	5	7[f]	52
Miami, U. of								1			1
Total	4	3	7	11	3		7	6	5	7	53

a Program authorized.
b Agric. engrg. 8; nuclear engrg. 15.
c Ocean engrg. 25.
d Archit. engrg. 5.
e Agric. engrg. 1; nuclear engrg. 9.
f Nuclear engrg. 7.
g Incl. degrees in Industrial Engineering and in Operations Research.
h Incl. degrees in Environmental Engineering Sciences.
i Incl. BS and MS degrees in Engineering Science, and MS and PhD degrees in Engineering Mechanics

Source: Engineering Degrees and Enrollments, USOE, EMC.

institutions offer curricula in Oceanography, Marine Science, Marine Biology, etc., outside of engineering.

It is recommended that the Chancellor's Office undertake a review of all of the present programs in Florida that are related to the ocean, and develop a blueprint for the future development of various aspects of this broad subject at both undergraduate and graduate levels. This should be done with the objective of consolidating the State's activities in a way that optimizes the use of resources. In general, strong specialization should be reserved largely for graduate programs.

At undergraduate level, instruction relating to the ocean and ocean engineering can in most cases be appropriately handled as an option within an existing broader major. Thus when appropriate, a Biology Department can provide an undergraduate option in Marine Biology. Again, undergraduate and graduate Coastal Engineering can be an option within Civil Engineering and is so handled at several institutions in the country.

Graduate work related to the ocean should be concentrated at one institution, which would then be provided with the resources required to achieve a real steeple of excellence. What is to be avoided is duplicating or overlapping graduate programs at two or three institutions. Because of its unique geographical location, the State of Florida should have one of the really great centers in the country for the study of the ocean, at which all available State resources are concentrated.

2.5 Quality of Engineering Education Available in Florida. In recent years, fairly reliable national ratings have been available on the quality of graduate programs in certain engineering fields with respect to: (*a*) the qualifications of the faculty for carrying on graduate-level work, and (*b*) the attractiveness of the graduate programs from the student's viewpoint.[1] These ratings represent the consensus of large, carefully chosen panels, and accordingly have a high degree of legitimacy.

[1]Kenneth D. Roose and Charles J. Anderson, A Rating of Graduate Programs, American Council on Education, 1970. For earlier ratings of the same character, see Allan M. Cartter, An Assessment of Quality in Graduate Education, ACE, 1966.

The only Florida institution presently having any national visibility in engineering is the University of Florida. This is not unexpected, since no other school in the State has had a doctoral program in engineering. The ratings received by the University of Florida in engineering are given in Table 2-3. It is seen that there has been improvement from 1964 to 1969. When its 1969 ratings are compared with those of other institutions, the University of Florida would certainly rank among the top 35 institutions in the country in engineering, but would not be in the top 25.[1, 2] This corresponds to an institution that could fairly be considered "good," but not "distinguished."

Table 2-3

QUALITY RATINGS OF GRADUATE PROGRAMS IN ENGINEERING
UNIVERSITY OF FLORIDA

Program	1969 Ratings *(a)*		1964 Ratings *(b)*	
	Quality	Effectiveness	Quality	Effectiveness
Chemical Engineering	18-38	19-58	Below 41	Below 37
Civil Engineering	37-56	14-48	16-29	12-35
Electrical Engineering	24[1]	24-57	32-44	15-37
Mechanical Engineering	39-58	16-52	Below 38	Below 36

[1]Tie with four others.

Note: 18-38 means rating is somewhere between 18th and 38th places.

Sources: *(a)* Kenneth D. Roose and Charles J. Andersen, A Rating of Graduate Programs, American Council on Education, Washington, D. C., 1970.

(b) Allan M. Cartter, An Assessment of Quality in Graduate Education, American Council on Education, Washington, D. C., 1966.

[1]This is consistent with other criteria of quality, such as number of winners of NSF Graduate Fellowships in engineering that choose to study at the University of Florida, number of NSF Traineeships awarded in engineering, etc.

[2]In specialized unranked areas of knowledge relating to the ocean, such

No ratings are available on the quality of undergraduate instruction. However, some correlation is generally considered to exist between undergraduate quality and the quality of the graduate program that a faculty is able to provide. This makes the assumption that faculty members who are recognized as leaders in their specialties are likely to be better undergraduate teachers of these same subjects than less well qualified faculty members.[1] However, faculty members with doctoral backgrounds or the equivalent, but who have lesser distinction or who are yet too young to have gained national recognition and have an interest in teaching, can be expected to do a workmanlike job of undergraduate teaching. On this basis, all of the public institutions in Florida are believed capable of offering undergraduate engineering programs of acceptable quality. This view is further reinforced by the fact that in undergraduate programs the quality of the students is as important as the qualifications of the faculty, because student ability sets the minimum standards for teaching. In this connection, the public institutions of Florida are in a favorable situation, since there is a statewide requirement that all entering freshmen be in the top 40% of high school graduates (corresponding to a score of 300 on the Florida Twelfth Grade Test). Further, certain institutions, notably University of Florida and Florida State University, have minimum standards even higher than those represented by the State test.

2.6 Engineering Research. Expenditures in sponsored engineering research programs in Florida institutions for the year 1969-70 are listed in Table 2-4. It will be noted that these expenditures are largely concentrated at the University of Florida, with University of South Florida being a clear second, though trailing far behind.

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as Ocean Engineering, Coastal Engineering, and Oceanography, Florida institutions as a group, and also individually, do have a distinctive position. However, this is obtained more by default than by achieving a top ranking in a strongly competitive situation.

[1] There are, of course, many individual exceptions to this statement.

Table 2-4

SPONSORED RESEARCH EXPENDITURES IN ENGINEERING
1969-70

Florida, U. of	$4,163,300[1]
Florida Atlantic	3,320[2]
Florida State	45,000[4]
Florida Tech. Univ.	48,000
Univ. South Florida	271,000
Embry Riddle	-0-
Florida Inst. Tech.	19,000
Miami, Univ. of	90,000[3]

[1]Incl. $500,000 State appropriation for Engineering and Industrial Experiment Station plus approximately $1,000,000 of other non-federal funds.

[2]Does not incl. two-year $180,000 NSF Sea Grant (for instruction in Ocean Engineering), and $4,600 for instructional equipment.

[3]Does not incl. research by Ocean Engineering faculty conducted in School of Marine and Atmospheric Sciences.

[4]Approximate.

Source: Questionnaire.

The research funds listed in Table 2-4 add up to 1.6% of the total research expenditures of US engineering schools, whereas Florida has 3.35% of the US population. This is further confirmation of Florida's lack of strength in engineering education discussed in Sec. 2.5.

Research expenditures are to a considerable degree a measure of an institution's readiness to handle a doctoral program. This is because such funds support graduate students and research assistants, and cover the operating expenses associated with quality research. Further, the ability of faculty members to obtain research grants and contracts, particularly federal funds, under the usual competitive conditions, provides an indication of faculty qualifications. From this point of view, the University of Florida is clearly in a position to handle doctoral work.

However, the other Florida institutions, with the possible exception of South Florida, need to strengthen their sponsored research programs substantially before considering establishing regular doctoral programs in engineering.

2.7 Part-time Degree Programs for Employed Engineers. Florida has lagged behind most states in providing part-time programs whereby employed engineers can obtain master's degrees. Several factors have contributed to this situation. Geographical considerations make it impossible to serve existing needs from any reasonable number of campus locations. The only institution in the State that offered graduate work in engineering until comparatively recently, namely the University of Florida, is located where there is relatively little industry. Again, while the University of South Florida and the University of Miami are in populous areas, their graduate work in engineering is of comparatively recent origin, and thereby lacks the maturity, diversity, and the academic strength required to provide really good service to industrial employees.

In 1963, the Florida Legislature acted to improve this situation by providing a legal basis for the College of Engineering of the University of Florida to offer graduate instruction in degree programs in the east central area of Florida. This resulted in the establishment in 1965 of GENESYS, a closed-circuit talkback television system that initially made graduate courses available to Orlando, Daytona Beach and Cape Canaveral. In 1969 GENESYS was extended to West Palm Beach, and in September 1970 to Boca Raton. GENESYS represented an innovative breakthrough in the application of new technology to engineering education. However, as discussed in Chapter 3, GENESYS in its present form only partially meets Florida's need for graduate-level instruction in degree programs for employed engineers.

2.8 Level of Interest in Engineering at Florida Institutions. The level of interest in engineering on the part of undergraduate students is indicated by the ratio of bachelor's degrees awarded in engineering to the total number of baccalaureate degrees awarded to men in all fields. Data of this character pertinent to Florida are given in Table 2-5. The level of engineering interest at Florida institutions of higher education when taken as a group is substantially below that in the United States as a whole, or in the adjacent States of Alabama and Georgia. There is considerable evidence to indicate that many young Floridians interested in engineering go out of state for their undergraduate work, while very few out-of-state residents come to Florida for undergraduate engineering.[1]

Level-of-interest data for individual "general" campuses in Florida are also given in Table 2-5. It will be noted that the University of Florida presents a strong engineering image to young Floridians--a result of its long-time dominance in engineering in the State. On the other hand, the remaining public institutions in Florida, as well as the University of Miami, show a comparatively low level of interest in engineering, indicating that they have considerably less-than-average drawing power as places to study engineering. As previously indicated, the overall State average is low.

The especially low level of engineering interest at Florida State and Florida Atlantic reflects the difficulty mentioned in Sec. 1.10 of attracting undergraduate students to a campus offering only one highly specialized engineering curriculum. This situation should improve at FAU as recently approved undergraduate programs in Electrical and Mechanical Engineering get established.

The weak engineering image possessed collectively by Florida's system of higher education is the result of a number of factors. First,

[1]Thus a survey showed that in 1968, 751 residents of Florida were enrolled as undergraduate engineering students at Georgia Institute of Technology. While this institution has a long tradition in engineering, and is a leading school in the Southeast, it is still not one of the top 25 engineering schools in the country. Table 2-10 highlights the inability of Florida's public institutions to attract out-of-state undergraduate engineering students.

Table 2-5

LEVEL OF INTEREST IN ENGINEERING

	BS(Engineering) / All Baccalaureate Degrees (Men)
General:[1]	
Entire US	10.6%
Florida	7.7
Florida + Alabama + Georgia	10.2
Individual Florida Institutions:[2]	
University of Florida	16.7
Florida Atlantic	3.1
Florida State Univ.	2.1
Florida Technological Univ.[3]	-
Univ. South Florida	6.6
Univ. Miami	7.0

[1] 1967-68 data.
[2] 1969-70 data.
[3] No normal engineering class yet graduated.

Source: Earned Degrees Conferred, USOE; Questionnaire.

as indicated in Sec. 2.5, no engineering school in the State ranks in the top 25 engineering schools, and only the University of Florida has any national visibility whatsoever in engineering. Second, Florida has been a latecomer in developing really significant graduate programs in engineering. Third, there is a lack of really close relations with industry. Fourth, there is no pacesetting institution in the State, or even in the entire southeastern area of the country to provide an example; not a single institution anywhere in the part of the south that is east of Texas ranks among the top 25 engineering schools in the country.

2.9 Capacity Available To Handle Increased Engineering Enrollments. All of the engineering schools of Florida are underpopulated with students in relation to the available facilities, equipment, and staff; each would accept more students if qualified applicants were available. This is particularly true at the public institutions.

The prospect for any substantial increase in undergraduate enrollment in engineering is limited; as indicated in connection with Fig. 1-1, engineering is not likely to be an expanding field of study in the decade ahead. While Florida can be expected to get a slowly increasing share of the national total because of disproportionate population growth, it is apparent that Florida acted hastily when, in the decade ending in 1968, it increased from one to five the number of publicly supported institutions offering BS degrees in engineering. It would have been a more prudent policy to have expanded engineering more slowly, on a step-by-step basis in which each additional step was taken only as the last step had achieved an ongoing program having an adequate student population. <u>Looking ahead, Florida should certainly not introduce engineering on additional campuses until the present situation is in better balance</u>.

As previously noted in Sec. 2.4, all graduate engineering programs in Florida are underpopulated. More master's and doctoral students could accordingly be handled at little incremental instruction cost. In this connection, the expansion in the number of full-time-on-campus graduate students would require an increase in student support funds, which in turn would call for more sponsored research and better use of existing funds. The enrollment of part-time students depends on the availability and attractiveness of suitable programs, and could be increased by means described in Chapter 3.

2.10 <u>Special Opportunities for Gifted High School Graduates</u>. Several Florida institutions offer specially gifted high school students special treatment. Thus, Florida Atlantic, which is an upper division university, admits a small number of especially promising high school graduates into a program that leads to a bachelor's degree at the end of three years. Again, the University of Miami similarly admits selected high school students at the end of their junior year and gives them full freshman standing so that they can receive the bachelor's degree after four years spent at Miami. Reports received on these programs indicate that a high proportion of such students are engineers, and that these young people do unusually well in their university studies.

These are innovative approaches to education that are to be commended. As experience is gained with such programs, consideration should be given to enlarging them, and also to extending them to other institutions.[1]

2.11 Time Required To Obtain the BS Degree. So-called "four-year" BS programs in US engineering schools all too frequently require the typical student in fact to spend more than the advertised four years. Data on this subject as reported by Florida institutions are given in Table 2-6 and are far from satisfactory. The worst situation appears to exist at the University of Florida, where of those students graduating in 1969-70, and "who entered as regular freshmen without subject matter deficiencies for engineering and who from the beginning of their college careers were tending toward engineering," 81% required five or more years (15 or more quarters)[2] to complete the "four-year" curriculum!

At Florida Atlantic, which is an upper-division university, most students take 7 quarters to graduate in engineering after entering as fully qualified juniors. Practically none complete the program in the advertised 6 quarters; a moderate number take still more time, but most of these latter have entrance deficiencies.

Requiring a satisfactory student to spend 4-1/3 to 5 years to obtain a BS in engineering is both unfair to the student and expensive to the State. It would be better all around if students in good standing actually graduated at the end of 12 quarters, and could earn master's degrees in engineering at the end of the 15th quarter.

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[1]The admission of high school juniors to a university must, however, be handled with great care if the high schools are not to be alienated. The University of Chicago had an unfortunate experience in this matter.

[2]A reduction of 12 units in the requirements for graduation made in 1970 will cut approximately one quarter from the time to the BS in the future However, even with this improvement, the time to the BS will still be excessive.

Table 2-6

TIME REQUIRED TO OBTAIN B.S. IN ENGINEERING[1]
1969-70 GRADUATES

	12 Qtr. or less	13 Qtr. or less	14 Qtr. or more	15 Qtr. or more	8 Sem. or less	9 Sem. or less	10 Sem. or more
University of Florida	1.3%	8%	92% *b*	81% *b*			
Florida Atlantic Univ.	*a*	*a*	*a*	*a*			
Florida State Univ.	16%	45%	55%	36%			
Univ. South Florida	9%	32%	68%	14%			
Univ. Miami					45%	71%	29%
Florida Inst. Tech.	83%	90%	10%				

(a) This is an upper division university; most engineering graduates of 1969-70 who entered without deficiences took 7 quarters to obtain a BS.

(b) These percentages will go down somewhat in future years as the result of a reduction of 12 units in the requirements for graduation made in 1970.

[1]For those who entered as regular freshmen without subject matter deficiencies for engineering, and who from the beginning of their college careers were tending toward engineering.

Source: Questionnaire.

2.12 Instruction Cost and Productivity Indices. Values of direct instruction cost per student credit hour as reported for engineering colleges in Florida are given in Table 2-7, together with comparable data available on several other representative institutions.[1] The costs shown are all reasonable in relationship to associated circumstances, and are typical of corresponding institutions around the country. Whatever major differences there are between individual Florida institutions have obvious explanations. Thus of the public institutions, Florida State has the highest costs because it offers a rather comprehensive selection of courses at graduate level in Engineering Science wherein enrollments are very low (average of five students per class). Direct instruction cost at the University of Florida is also higher than the average in Florida in spite of a large engineering enrollment; this is because of the extensive proliferation of departments and curricula at this institution. In contrast,

[1]The significance of such data is discussed briefly in Sec. 1.9, and in greater detail in the journal article reproduced in part in Appendix A.

Table 2-7

DIRECT INSTRUCTION COST PER STUDENT CREDIT HOUR

1969-70

	Dir. Inst. Cost (Thous.)	Qtr.Cr. Hrs. (Year)	Inst. Cost per Qtr. Cr.Hr.	Engrg. Degrees BS	Engrg. Degrees MS	Engrg. Degrees PhD	Comments on curricula
Florida institutions:							
Florida Atlantic	$161	5,740	$29	25	-	-	Sgl. curric. w/o grad. work
Florida State	238	5,575	43	39	12	-	Sgl. curric. w/ grad. work
Florida Tech. Univ.	292	11,692	25	3[3]	-	-	Gen'l. engrg. w/o grad. work
Univ. Florida	2,223[4]	59,194[4]	38[4]	391	114[4]	53	Eleven degree-granting depts.
Univ. So. Florida	564	19,861	28	96	37	-	Gen'l. engrg. w/ grad. work.
Embry-Riddle	76	NA	NA[5]	34	-	-	Sgl. curric. w/o grad. work
Florida Inst. Tech.	198[2]	7,500[2]	26[2]	49[6]	26[6]	-	Two curric. w/ grad. work
Univ. Miami	615	18,408[1]	33	122	22	1	5 UG, 4 grad. curric.
Some other institutions (adjusted to 1969-70 salaries)							
Stanford			$41	115	558	167	
Univ. Cal. (Berk.)			52	461	439	110	
Univ. Buffalo			40	168	65	12	
San Jose State			28	194	71	-	
City Coll. New York			32	401	84	10	
Cornell Univ.			41	328	247	74	
Rensselaer (Troy)			27	401	180	37	
Univ. Rochester			49	48	65	22	

NA Not available.
[1]Converted from semester to quarter hours.
[2]Includes Electrical Engineering and Space Technology.
[3]First engineering students enrolled fall 1968.
[4]Does not include GENESYS.
[5]Adequate data not available, but cost is very low.
[6]Electrical Engineering only.

Sources: Questionnaire; F. E. Terman, A Study of Engineering Education in California, March 1968; F. E. Terman, Engineering Education in New York, March 1969.

instruction costs at Florida Technological University and University of South Florida are low because these institutions have limited their course offerings to the mainstream areas of engineering and have sim ' ·neously avoided undue proliferation of offerings wi.hin these areas.

Among the private institutions, University of Miami costs are slightly high since its limited number of engineering students are currently distributed among six different fields of engineering, including five at bachelor's and four at master's levels. As a result, it suffers from an undersupply of students in relationship to breadth of offerings. Costs at the Florida Institute of Technology are low because there is only a single engineering curriculum; also a significant part of the teaching at this institution is handled by part-time faculty from industry, which helps keep expenses down.

Statistics on teaching productivity, i.e., student credit hours per faculty member per term, are presented in Table 2-8. The results for Florida institutions are consistent with the data on direct instruction cost per student credit hour of Table 2-7, when allowance is made for the fact that at the University of Florida (but at no other Florida school) a significant portion of the faculty payroll is charged to research projects, so many faculty members are in fact teaching only part time. However, when the University of Florida figure is compared with data from "Some Other Institutions" in Table 2-8 where faculty members are heavily engaged in research (such as Stanford, University of California at Berkeley, Cornell, etc.), the teaching productivity of the University of Florida faculty tends to be on the low side. This is a result of the proliferation of departments and curricula at the University of Florida, as discussed in Sec. 4.3 (pp. 84-85).

Productivity in the doctoral program at the University of Florida has ranged between 0.2 and 0.3 doctorates per faculty member per year during the last several years. This is about what is to be expected from an institution ranking in quality somewhere between 25th and 35th in the country. Such an index of PhD productivity is consistent with the assumption that only a minority of the faculty at the University of Florida is reasonably active and productive in academically oriented research.

Table 2-8

TEACHING PRODUCTIVITY

1969-70

	Qtr.Cr. Hrs.	Faculty (Regular) α	Faculty (Total) β	SCH/Term / Faculty (Reg.)	SCH/Term / Faculty (Total)
Florida Institutions:					
Florida Atlantic	5,740	12.5	13.5	153	142
Florida State	5,575	15	18.5	124	100
Florida Tech Univ.	11,692	21	?	186	?
Univ. Fla.	59,194[3]	181[5]	253.5	109	78
Univ. So. Fla.	19,861	33	39.5	201	168
Embry-Riddle	NA	5	7	NA[4]	NA[4]
Fla. Inst. Tech.	7,500[2]	10	?	250	?
Univ. Miami	18,408[1]	42	50.8	146	121
Some Other Institutions:					
Stanford				126	
Univ. Cal. (Berk.)				124	
Harvard				114	
Cal Tech.				67	
MIT				108	
Buffalo				140	119
CCNY				245	161
Cornell				138	1[illegible]6
Rensselaer				161	137
Rochester				89	78

α Regular faculty incl. only assistant, associate, and full professors (head count).
β Total faculty incl. regular faculty plus equivalent full-time adjunct and visiting faculty, lecturers, and teaching assistants.

NA Not available.

[1]Converted from semester to quarter hours.
[2]Estimated.
[3]Does not include GENESYS.
[4]Adequate data not available, but is very high.
[5]Does not include 2.7 on leave of absence.

Sources: Questionnaire; F. E. Terman, Engineering Education in New York, March 1969; private communications.

2.13 The Impact of the Junior College on Engineering Education in Florida. Florida has a very highly developed system of junior colleges which is providing greater numbers of upper division engineering students to senior colleges and universities than is customary elsewhere in the country. Moreover, the Florida engineering deans anticipate the input from junior colleges will in the years immediately ahead expand more rapidly than will the input of freshmen.

Although there is general satisfaction with the quality of the pre-engineering graduates of the better junior colleges, it is not entirely clear that the final answer on this point has been obtained. Problems relating to counseling admittedly exist within the junior colleges. In addition, these institutions have difficulty offering satisfactory sophomore-level introductory engineering courses. In this connection, the common practice of deferring these introductory engineering courses until the junior year where they can be taken at the senior college is not an entirely satisfactory solution, since it tends to delay graduation.

It is important that the senior engineering colleges and the junior colleges work closely together with respect to articulation of subject matter in lower division work, and in counseling. In the articulation problem in particular, the senior and junior college people must work out their common problems as genuine equals; otherwise the junior colleges will regard "help" offered them as representing interference.

In some cases senior institutions may be able to provide appropriately planned sophomore introductory engineering courses to junior colleges in their region using videotape and GENESYS techniques, such as described in Chapter 3.

2.14 Accreditation of Undergraduate Engineering Programs. The recognized mechanism for accrediting undergraduate engineering programs is through the Engineers Council for Professional Development (ECPD). While accrediting, per se, is not necessarily all-important, failure of an institution to have at least one of its engineering programs accredited by ECPD is conspicuous through its absence. As of the beginning of 1971, the accredited undergraduate programs in Florida were those given in

Table 2-9. No undergraduate engineering programs at South Florida, Florida Atlantic, Florida State, or Florida Technological University have received ECPD approval. Continuing programs at these schools should therefore give high priority toward meeting the criteria for accrediting at least one undergraduate engineering program.

In connection with accreditation, it needs to be realized that such recognition, even when granted, does not imply that the program is especially outstanding: rather ECPD accreditation merely implies that the program in question meets a minimal standard. At the same time, it is also to be kept in mind that certain special types of engineering curricula may not be particularly appropriate for accreditation. For example, an unconventional highly permissive option may not conform to the pattern expected by the accrediting authorities, even though it is a good program for the purpose intended. Lack of accreditation for such a program need not be an embarrassment; on the other hand, failure of more standard curricula to be accredited does call for some explanation, and perhaps improvement.

Table 2-9

E.C.P.D.-ACCREDITED B.S. PROGRAMS IN FLORIDA

(as of September 30, 1970)

University of Florida	University of Miami	Florida Inst. Technology
Aerospace	Architectural	Electrical
Agriculture	Civil	
Chemical	Electrical	
Civil	Industrial	
Electrical	Mechanical	
Engrg. Science		
Industrial		
Mechanical		
Metallurgical & Materials		
Sanitary*		
Systems		

*Program terminating in MS degree in environmental engineering.

Source: Engineers Council for Professional Development.

2.15 Authorization of Master's Programs. Once an institution has had one or more of its undergraduate engineering curricula accredited, it should then be both permitted and expected to develop a master's degree program of at least limited scope, if it has not already started doing so. As previously noted (Sec. 1.2), a master's degree has become the preferred preparation for the general practice of professional engineering. Accordingly, it makes no more sense for Florida to support an undergraduate engineering program and not allow this program to extend to the master's degree in at least some areas, than it does to support a Law School which is not allowed to offer the final year of the Law curriculum. It is not necessary that graduate specialization be permitted in every area in which undergraduate instruction is offered, but the natural progression is for graduate work to be available in areas that do reflect undergraduate emphases. A faculty capable of offering an undergraduate program of good quality should be qualified to offer acceptable courses at the MS level.

The breadth of a master's degree program can often be improved by making use of part-time lecturers from local industry as adjunct faculty. Also, when courses originating from other campuses are available through GENESYS or through videotape techniques (see Chapter 3), it is possible to enrich an emerging master's degree program at only nominal incremental cost. Such opportunities should be actively sought and exploited to the limit of their possibilities.

2.16 Establishment of Doctoral Programs. The State University System of Florida has certain minimum requirements that must be met before formal authorization of a doctoral program can even be requested. In engineering, considerations relating to sponsored research should also be taken into account when reviewing proposals for establishing doctoral work.

Looked at in broad perspective, a college of engineering is prepared and qualified to offer a doctorate in an area of engineering in which it has (*a*) an accredited undergraduate program (presuming it awards BS degrees in that same field); (*b*) an established master's degree program (either with or without thesis) in that field through which there is a reaonable flow of students; and (*c*) a group of faculty members who are carrying on creative professional engineering work in that field. This last requirement normally means research supported by contracts and grants that have been obtained from government agencies in competition with other applicants. Until the department or faculty group has developed such a re earch program involving a significant amount of outside sponsorship, there is a serious question as to whether it is ready and/or qualified to conduct work at the doctoral level. Moreover, unless there is a reasonable volume of research funds available to support doctoral students as research assistants, there will be few students in the doctoral program, even if one is authorized.

When a department (or division) within a college of engineering does meet the requirements listed above, it should as a matter of course be authorized to offer the doctorate. At the same time, such authorization does not require additional funds or faculty to be provided, since at the time of authorization there is already an on-going research program with funding to take care of the research expenses, and also an on-going master's program to provide an adequate background for classroom instruction of the doctoral students. Under these circumstances, a respectable doctoral program can be carried on at little additional expense to the State, and with considerable benefit to the academic institution and to the clientele it serves. Administrative procedures should be modified to reflect this situation.

There are circumstances where it is not appropriate to give a blanket authorization to a department (or division) of an engineering school to award doctor's degrees, yet where there is a faculty member who has a high level of competence, who is conducting research with the aid of grants or contracts received on a competitive basis, and who is using master's degree students to help in this research. In such a situation, it will frequently happen that this professor is in a position to turn out a fully qualified PhD every year or so at no extra expense to the State, while concurrently upgrading the stature of the academic program on his campus, and gaining personal satisfaction in the process. Procedures for approving doctoral candidates under such circumstances should be developed, based on a case-by-case review for each individual student. Approval would presumably be given by the Chancellor's office, possibly with the help of a neutral Advisory Committee, under appropriate guidelines that would safeguard quality and prevent abuses. Acceptable proposals might require: (*a*) that the faculty supervisor have satisfactory standing in the field of engineering involved as indicated by refereed publications or other acceptable evidence; (*b*) that the proposed dissertation will be part of an on-going program adequately supported by extramural funds, so that the proposed research of the doctoral student can be carried out without special support from State funds; (*c*) that the student candidate have the requisite qualifications; and (*d*) that the professor who will supervise the student's research be prepared to guide the candidate on a tutorial basis without exacting special dispensations with regard to his other duties. When these conditions are met in an individual case, approval should not be unreasonably withheld.

If a "PhD Special" procedure of this type is established, it would give a department the opportunity to develop a record that could ultimately justify a blanket authorization for the PhD, while withholding general approval until it is clear beyond any doubt that the department is ready. The "PhD Special" approach would also be useful in connection with unconventional programs as well as interdisciplinary programs.

2.17 Cooperative Programs. A number of the Florida institutions offer undergraduate cooperative programs in which undergraduate students alternate work periods in industry with full-time study on the campus. There is much to be said in favor of this pattern of engineering education. "Co-op" students are largely self-supporting through their earnings during the work periods. In addition, the work experience has educational value, so that upon graduation co-op students are generally better adjusted to the outside world than is the usual esh college graduate. As a result, many employers look with special favor on them.

Where other things are equal, co-op programs are accordingly to be encouraged. On the other hand, it is difficult to operate a co-op program efficiently unless the number of undergraduate students involved is large, since the alternating work periods make it necessary to offer many courses at least twice a year. Hence when the number of students is small, the imposition of a co-op structure on the curriculum can raise costs very substantially, and is therefore of questionable desirability.

2.18 Residence of BS Engineering Graduates. Table 2-10 shows the extent to which BS engineering graduates of Florida institutions are: (*a*) out-of-state residents, and (*b*) resident within commuting distance from the school at which they study. It is seen that the public institutions attract very, very few out-of-state students. Also, among the public institutions, Florida Atlantic, Florida Technological University, and South Florida cater to a student body that is heavily local, whereas University of Florida and Florida State do not.

In contrast, the clientele of the private institutions is primarily non-local, with a high proportion of out-of-state students.

Table 2-10

RESIDENCE OF ENGINEERING B.S. GRADUATES OF FLORIDA INSTITUTIONS 1969-70

Institution	Residence out of state	Residence within 25 miles of institution
Florida Atlantic	12%	64%
Florida State	3	6
Florida Tech. U.	-	app. 90
Univ. Florida	4	10
Univ. So. Fla.	2	80
Embry-Riddle	95[1]	1
Fla. Inst. Tech	25	30
Univ. Miami	48	25

[1]Many of these are foreign.

Source: Questionnaire.

2.19 <u>Some Observations Regarding Florida Industry</u>. Florida has experienced a significant industrial development in recent years. Many prominent national firms, such as General Electric, IBM, Westinghouse, RCA, etc., have large plants in Florida. However, the associated operations tend to be strongly oriented toward design and manufacturing, with most and sometimes all of the related research and advanced development being done elsewhere. Important government installations (e.g., Kennedy Space Center, Naval Training Devices Center, Naval Air Station at Pensacola) are located in Florida. These are variable in character; they include some high level engineering but also much that is essentially service and operating activity.

In addition, a number of indigenous technology-oriented firms have begun to emerge in the State in the last few years. These are still generally small or modest in size, but some appear to have promising futures and may grow to become concerns of major national importance. They accordingly have the potential for molding the character of Florida industry, and in the process can influence the character of activities carried on in the branch plants of national concerns.

In summary, Florida has the potential of becoming one of the nation's centers for high technology industry. A start has been made, and such factors as living conditions are favorable. However, for Florida industry to develop in this direction it needs a stronger technological base than now exists.[1]

Engineering colleges in Florida can make a major contribution to the future of the State. As stated on p. 19, engineering education is an all-important raw material for technology-oriented companies that have ambitions. Strong engineering and applied science programs at the State's educational institutions, and high quality, well thought-out course offerings for part-time students employed in industry are of critical importance to Florida. Expenditures to provide the educational

[1] The membership roster of the National Academy of Engineering points up the lack of technical leadership in Florida. Of the approximately 350 NAE members, none are Florida residents who have not retired.

backup that is required by a vigorous and growing high technology industry should be regarded as a capital investment in the future of the State which will pay large dividends over the years.

The efforts that have been made to date in Florida to provide part-time educational opportunities for employed engineers have focused heavily on large companies, and on aerospace subject matter.[1] Increased attention needs to be given to serving a broader spectrum of engineering activities in the State, including not only the small and medium-sized high technology firms, but also other industries that utilize engineers, such as construction, consulting, food technology, extractive operations, city plannnng, and general manufacturing. This means increasing the breadth of part-time programs available, with particular emphasis on including industrial engineering and engineering management subjects, civil engineering, chemical engineering, design, materials, etc.

[1]This is pointed up by the data in the footnote on p. 60.

Chapter 3

GENESYS

GENESYS is a system of closed-circuit talkback television devised at the University of Florida to bring graduate-level instruction for credit to locations remote from the academic campus. GENESYS is of enough importance and potential to Florida to justify special consideration.

3.1 Description of the GENESYS System. By the early 1960's a substantial amount of science-oriented industrial activity had developed in east central Florida. As a result, graduate work in degree programs was urgently needed to serve engineers working in the area who desired to study part-time for advanced degrees. Since there were no suitable educational institutions in east central Florida, the Florida Legislature in 1963 authorized the College of Engineering of the University of Florida to operate appropriate engineering programs there.

After considering various alternatives, the then dean of engineering, Thomas L. Martin, decided upon a system of closed-circuit talkback television tailored to the specific task at hand. GENESYS (Graduate Engineering Education System) resulted, and the system was placed in operation in early 1965. GENESYS emphasizes a normal classroom environment in the originating studio classroom, where bona fide students sit before the professor in a room that is much like any other classroom in that there are no spotlights, no cameramen, no camera booms, no makeup, and no rehearsals. Television camera tubes are mounted in the ceiling and in the back wall; these are supervised by a student operator (or a TV technician) who observes the classroom through a plate glass window and manipulates the camera tubes by remote control. In this situation, the professor does not feel "on stage" and performs much as he would in any ordinary classroom. At the same time, the fact that he knows he is on television and does not know who may be watching, characteristically causes him to prepare lectures more carefully and to deliver them better. Thus, the television system contributes subtly to better teaching.

The program is transmitted to receiving points over circuits leased from the Bell System. Students at the viewing locations are provided with pushbutton microphones that enable them to talk back to the originating classroom. In this way, the students in the viewing rooms not only hear class discussions, but can participate in them, and can even interrupt the lecture to ask questions or initiate discussions. The student attending the class via "electronic residence" is thus in actual fact a real member of the classroom group. These students, moreover, do homework and take examinations concurrently with the students in the studio classroom. A courier or mail system is used to distribute and collect papers. Studies show that performance on examinations and in homework of the students in "electronic residence" exhibits no detectable difference from the performance of students with equal qualifications who receive the course directly from the professor in the "studio classroom."

GENESYS originally linked Gainesville with Centers at Cape Canaveral, Daytona Beach, and Orlando; subsequently in 1969, the system was extended to West Palm Beach and in 1970 to Florida Atlantic University at Boca Raton. At each location away from Gainesville (except at Florida Atlantic University), there is a classroom building that provides suitable viewing rooms, a studio classroom equipped to originate a program, laboratories, an analog computer, digital terminals, a small library, and offices. There are also two to four University of Florida faculty members resident at each such Center who act as local representatives of the University's College of Engineering.

Each link of the system is capable of simultaneously transmitting one program in each direction. Classes thus originate not only at Gainesville, but also at the Centers. Instruction originating at the Centers is provided by the locally resident University of Florida faculty members, supplemented to a limited extent by lecturers from industry.

3.2 Subsequent Developments: ITFS and Videotape Systems. GENESYS was an immediate success and soon attracted considerable attention. In 1966, Dr. Martin became Dean of Southern Methodist University's Institute of Technology, where he stimulated the development of an educational television system analogous to GENESYS to serve the Dallas-Fort Worth area. This system, called TAGER (The Association for Graduate Education and Research), differs from GENESYS in that television viewing rooms are located in the industrial plants where part-time students work; the students from industry are thus not required to commute to a centrally located classroom. The TAGER system also includes engineering improvements in studio classroom and viewing room design, based on experience with GENESYS.

The GENESYS-TAGER concept has been widely copied in the last few years Thus, in 1969 Stanford placed in operation a system similar to TAGER, but with the signals broadcast to industrial plants through the newly available ITFS (Instructional Television Fixed Service) channels in place of the closed-circuit techniques of GENESYS and TAGER.[1] Subsequently, analogous sytems have been placed in operation by the City University of New York (closed-circuit), University of Michigan (broadcast), University of Minnesota (closed-circuit) and SUNY-Buffalo (broadcast). The State of Oklahoma has appropriated a million dollars for a TV system that will interconnect four campuses and eight population centers. In addition, a dozen or so other schools are known to be working on the problem of funding similar systems. The trend is definitely toward in-plant viewing and broadcasting.

The success of GENESYS-TAGER has encouraged experimentation in the application of still other techniques. An example is provided by the SURGE system of Colorado State University, in which the television signals generated in a GENESYS-type classroom are recorded on videotapes, which are then distributed by courier or bus to various industrial plants, and replayed on a delayed basis. In this way, it is possible to serve employees of industrial firms that are dispersed over a wide geographical area without incurring the cost of leased lines or relay stations. While the SURGE type of arrangement has the disadvantage that there is no talkback, the SURGE students do get the benefit of the classroom discussions.

[1] In broadcast arrangements, talkback can be provided either by telephone circuits, or by frequency-modulated radio channels.

Performance on examinations and homework shows that the students at the remote locations learn just as much as do the students in the studio classroom.[1]

3.3 Data on GENESYS Operations. The enrollment history and degree data associated with GENESYS are given in Table 3-1. Both head count registrations and course enrollments have been fairly constant, but would have dropped off in the last two years if it had not been for the opening up of a new Center at West Palm Beach.

Table 3-1

HISTORY OF GENESYS COURSE ENROLLMENTS AND DEGREES AWARDED

Year	Fall		Master's Degrees Awarded	New Students Admitted[1]
	Head Count	Course Enrollments		
1964-65	220	260	8	NA
1965-66	400	550	36	NA
1966-67	470	590	46	NA
1967-68	390	485	17	NA
1968-69	335	440	28	222
1969-70	375	515	34	257
1970-71	350	409	NA	222

[1]Incl. both degree candidates and non-degree students.

Source: College of Engineering, University of Florida.

The number of new students enrolling in the system in each of the last several years is seen from Table 3-1 to have held up quite well. The number of new enrollments is a substantial fraction of the total number of enrollees, indicating a fairly large turnover of GENESYS students.

[1]As of 1969-70, Colorado State University was providing this service at 16 in-plant locations to 300+ students enrolled for credit.

The number of master's degrees awarded through the GENESYS program is seen to be relatively small compared with the total enrollment at any one time, and also compared with the number of new students admitted to the program in any one year. An important factor contributing to this large attrition is the length of time required to complete the MS program when the student is enrolled for only a single course per term, which is the usual load for a GENESYS student. For those who received their degrees in 1969-70, the typical elapsed time was about 4 calendar years.

The number of courses offered, course enrollments, and sources of students in individual GENESYS courses are shown in Table 3-2 for the fall of 1970. Of the 42 courses listed for GENESYS, it will be noted that only 17, or 40% originated at the Gainesville campus. Nearly all of the remainder were provided by GENESYS instructors attached to the various Centers; only 3 were taught by adjunct faculty from industry.

One can question the philosophy which leads to a substantial fraction of the GENESYS offerings being provided by professors who work at the Centers, in isolation from their colleagues, and who from the record appear to be negligibly involved in sponsored research activities. It would seem preferable to obtain the bulk of the GENESYS offerings from the Gainesville campus where Florida's academic strength in engineering is located.

Of the 747 enrollments in GENESYS courses in Table 3-2, 409 represent students located away from Gainesville. This is an average of 9.7 per class--a surprisingly low number. One would expect that GENESYS, with its limited channel capacity, would carry only relatively popular courses that would have a much larger audience than is the case. For example, four of the courses listed had no enrollees outside of the originating studio, while several other courses had only one or two students outside of the originating studio. Such situations raise unanswered questions regarding the appropriateness of course selection, the quantity and quality of the service that the present GENESYS system is rendering, and the effectiveness with which the potential of GENESYS is being used.

Table 3-2

DATA ON GENESYS COURSE OFFERINGS

FALL 1970

Course	Total	Cntr.	Gaines.		Daytona		Orlando		Cape		WPB		FAU	
			S*	N*	S*	N*	S*	N*	S*	N*	S*	N*	S*	N*
STA 440	10	Cape	-	-	-	3	-	3	1	-	-	2	-	1
EE 641	4	Cape	-	2	-	-	-	2	-	-	-	-	-	-
EE 600	20	Cape		-	-	4	-	6	4	-	-	3	-	3
MS 547	29	Cape	-	21	-	3	-	2	3	-	-	-	-	-
MS 490	6	Cape	-	-	-	-	-	5	1	-	-	-	-	-
ME 561	12	Cape	-	10	-	-	-	1	-	-	-	1	-	-
ISE 551	41	Cape	-	27	-	2	-	2	4	-	-	6	-	-
MS 503	16	Cape	-	-	-	1	-	2	3	-	-	10	-	-
ME 655	16	Cape	-	10	-	-	-	1	2	-	-	3	-	-
EE 522	5	Cape	-	-	-		-	2	3	-	-	-	-	-
STA 610	13	Cape	-	8	-		-	1	3	-	-	-	-	-
EE 591	5	Cape	-	-	-	1	-	1	3	-	-	-	-	-
EE 665	21	Orl.	-	2	-	2	10	-	-	7	-	-	-	-
EE 634	12	Orl.	-	3	-	1	3	-	-	3	-	-	-	2
ISE 580	11	Orl.	-	5	-	1	3	-	-	1	-	1	-	-
ISE 402	37	Orl.	-	29	-	1	6	-	-	1	-	-	-	-
EE 591	11	Orl.	-	1	-	-	4	-	-	3	-	1	-	2
ISE 401	2	WPB	-	-	-	-	-	-	-	-	2	-	-	-
EE 522	12	WPB	-	-	-	-	-	-	-	-	3	-	-	9
MS 501	15	WPB	-	-	-	-	-	-	-	-	15	-	-	-
ME 651	12	WPB	-	-	-	-	-	-	-	-	12	-	-	-
EE 561	11	FAU	-	-	-	-	-	-	-	-	-	3	8	-
EE 623	14	FAU	-	-	-	-	-	-	-	-	-	-	14	-
EE 570	9	Day.	-	-	1	-	-	7	-	1	-	-	-	-
MS 501	5	Day.	-	-	1	-	-	2	-	2	-	-	-	-
ISE 611	18	Gain.	14	-	-	-	-	2	-	2	-	-	-	-
ISE 601	27	Gain.	22	-	-	1	-	2	-	2	-	-	-	-
ME 593	6	Gain.	5	-	-	-	-	1	-	-	-	-	-	-
EE 561	21	Gain.	10	-	-	-	-	5	-	6	-	-	-	-
EE 660	8	Gain.	6	-	-	1	-	-	-	1	-	-	-	-
ESM 673	7	Gain.	5	-	-	-	-	2	-	-	-	-	-	-
ISE 670	19	Gain.	14	-	-	-	-	2	-	3	-	-	-	-
EGC 671	32	Gain.	25	-	-	-	-	-	-	-	-	7	-	-
ISE 640	3	Gain.	-	-	-	-	-	-	-	1	-	1	-	1
ISE 604	20	Gain.	17	-	-	-	-	2	-	1	-	-	-	-
ENE 591	34	Gain.	19	-	-	3	-	3	-	6	-	3	-	-
EGC 601	14	Gain.	11	-	-	-	-	1	-	-	-	2	-	-
ESM 621	15	Gain.	10	-	-	-	-	2	-	2	-	1	-	-
ISE 650	43	Gain.	23	-	-	-	-	8	-	1	-	11	-	-
ISE 550	65	Gain.	25	-	-	3	-	5	-	8	-	20	-	4
ME 650	53	Gain.	9	-	-	-	-	-	-	1	-	43	-	-
ME 581	13	Gain.	5	-	-	-	-	-	-	1	-	3	-	4
Enrollment Total	747		220	118	2	28	26	72	27	53	32	121	22	26
Enrollmt. Total in ea. Cntr			338		30		98		80		153		48	
Courses used at each Center			17	11	2	15	5	26	10	20	4	18	2	8
Courses used - Total			28		17		31		30		22		10	
Enrollmt./available course			8.0		0.7		2.3		1.9		3.6		1.1	

*Studio
*Network

Source: College of Engineering, University of Florida.

The distribution of GENESYS degrees by field given in Table 2-2 also raises questions. The small number of degrees in Aerospace, Mechanics, and Mechanical Engineering, and the lack of any degrees at all in Civil Engineering, Materials, and Environmental Engineering would imply that GENESYS is serving a limited part of Florida's need for part-time study in engineering.

It will be further noted from the data in Table 3-2 that GENESYS makes negligible contribution to the instructional activities at Florida Atlantic University, where there is a GENESYS outlet, and no instructional contribution whatsoever to other schools in the State.

3.4 Cost of GENESYS. The GENESYS system as it is now operating is quite expensive in relatio to the services rendered. Actual expenditures for the year 1969-70, as given in Table 3-3, raise a number of issues. Thus, GENESYS funds of the order of $134,000 are used to subsidize GENESYS courses originating on the Gainesville campus. Since these courses are presumably needed by that campus for its own resident students, and therefore would be offered anyway in the absence of GENESYS, it does not seem proper to load the associated instruction cost onto the GENESYS budget. Further, by eliminating from the GENESYS budget the faculty members now associated with the Centers, and selecting all or nearly all of the GENESYS courses from the profusion of quality offerings already available at Gainesville, most of the $329,000 item in the GENESYS academic budget could be eliminated. Again, it is apparent that the physical maintenance of the Centers and their non-academic staffs represent a very substantial cost. To the extent that GENESYS studios could be located on the campuses of local universities, these expenses could be reduced to a small fraction of their present amount.

Direct instruction cost per student credit hour for the GENESYS operation is given in Table 3-4 as figured from various viewpoints. Comparison with Table 2-7 indicates that on any basis these costs are on the high side. This is due in part to relatively low enrollments in GENESYS classes, in part to the way costs are allocated, and in part due to the limited use GENESYS makes of the academic resources of the Gainesville

Table 3-3

GENESYS BUDGET

ACTUAL EXPENDITURES

1968-69

Expenditures for equipment and services:		
Leased wires	$154,000	
Other services, incl. travel and utilities	73,000	
Materials and supplies	21,000	
Miscellaneous (mainly eqpt. rental)	8,000	
Operating capital outlay	43,000	
		$299,000
Personnel expenditures:		
Instruction - academic	329,000[1]	
- non-academic	122,000	
Other personal services	42,000[2]	
Fringe benefits	31,000	
		524,000
Total expenditures		$823,000

[1]Breakdown:

GENESYS faculty stationed at Centers [From Questionnaire; incl. summer sal.]	$195,000 α
To Univ. Fla. engrg. budget for GENESYS courses provided from Gainesville	134,000 α

[2]Incl. about $15,000 for adjunct faculty at Centers [from Questionnaire; incl. summer salaries] plus about $4,000 for Teach. Assts.

α Approximate.

Source: College of Engineering, University of Florida

Table 3-4

GENESYS COSTS PER STUDENT CREDIT HOUR
1969-70

	Including Summer		Excluding Summer	
A. Direct instruction cost per student credit hour:				
a. Non-Gainesville students:				
Direct instruction cost	$214,000		$161,000	
Student credit hours	4,801		3,781	
Instruc. cost per student credit hour		$45		$43
b. Total instruction cost, incl. Gainesville students:				
Direct instruction cost	$354,000		$271,000	
Student credit hours	6,886		5,758	
Instruc. cost per student credit hour		$52		$47
c. Direct instruction cost charged to GENESYS for instruction of students at Gainesville only:				
Direct instruction cost	$140,000		$110,000	
Student credit hours	2,085		1,977	
Instruc. cost per student credit hour		$67		$56
B. Total GENESYS cost (instruction, line charges, non-academic personnel, utilities, etc.				
Total cost (actual)	$823,000			
Student credit hours (total including Gainesville)	6,886			
Total cost per student credit hour		$120		

Source: College of Engineering, University of Florida.

campus. *Note that if GENESYS received all of its instruction as a by-product of courses already available on the Gainesville campus, then on an incremental basis the instruction cost of GENESYS would be zero*, and the principal cost of GENESYS would be leased lines. However, GENESYS has built up organization, structure, and overhead, plus support for normal Gainesville instruction activities to the point where leased line costs are less than 20% of total GENESYS expenditures; thus, the line cost is little if any more than the subsidy GENESYS contributes to the cost of on-campus courses at Gainesville.

A comparison of Tables 2-7 and 3-3 also shows that instruction costs are so allocated that the *average instruction cost for Gainesville students enrolled in GENESYS courses is considerably more than the instruction cost for Gainesville students enrolled in non-GENESYS courses originating on their own campus!!*

3.5 *Present Status of GENESYS--Strengths and Weaknesses*. The original concept of GENESYS was an educational innovation of great importance. However, except for the extension of the system to West Palm Beach, and some token experimentation with videotapes, GENESYS today is technically identical with the prototype system placed in use in early 1965, whereas important advances have been made by other users of this concept.

This system (1965 model) has certain limitations and weaknesses that unnecessarily limit the service it can render in the State. Thus, while GENESYS brings the approximate equivalent of a University branch campus to a local region, it still requires the student to commute to a central location. In certain cases, the commuting time equals or exceeds the time spent in class, thus limiting the accessibility of the system to students. To reduce commuting time per week, GENESYS operates with 75-minute class periods; this makes it possible to offer a three-unit course with two instead of three round-trip commutes per week; however, as a consequence GENESYS class hours differ from the normal class hours on the Gainesville campus. Further, the necessity of commuting ordinarily limits students to an academic load of one course per term. In contrast, in systems with in-plant viewing rooms, students can readily carry two courses per term and thereby reduce the time required to obtain degrees; this also low r ttrition by keeping incentive high.

Again, the present GENESYS system has insufficient channel capacity to provide an adequate variety of courses.[1] At least two and preferably three courses from the Gainesville campus should be made available to viewing stations at any given time.

One of the most serious weaknesses of GENESYS is that although Florida's faculty strength in engineering is heavily concentrated at Gainesville as pointed out in Sec. 2.5, GENESYS as it presently operates generates more than half of the instruction at the off-campus Centers. This means that the GENESYS clients are not systematically getting the best engineering courses that the University of Florida is capable of offering. Thus, consider Electrical Engineering, which accounted for over half of the master's degrees awarded through GENESYS in 1969-70. Electrical Engineering is the strongest engineering department at the University of Florida, possessing real national distinction (Table 2-3). It also has the largest faculty and the largest graduate enrollment of any engineering department at Gainesville. Yet of the 13 EE courses available to GENESYS students in the fall of 1970 (see Table 3-2), only two were taught by Gainesville faculty, and these thirteen courses included only 24 enrollees from Gainesville. Electrical Engineering students at Gainesville accordingly receive their instruction from a resident faculty group that is quite distinguished, in classes almost entirely uncontaminated by GENESYS students. In contrast, GENESYS students sit in Electrical Engineering courses which include almost no Gainesville classmates, and which are taught by faculty mem s isolated from the distinguished group at the University of Florida. It is easy to decide which students travel first class, and which get tourist service.

The independent Centers away from Gainesville are not only expensive

[1]Thus in order to originate 20 courses from Gainesville under present conditions, classes begin at 6:30 a.m. and run until 10:20 p.m. Needless to say, this schedule is not popular with either students or faculty at Gainesville.

to staff and maintain, but in addition, the faculty members associated with them are isolated from the normal campus contacts that are so important in a university community. Wherever possible, these Centers should for academic reasons be associated with local universities, entirely aside from the cost savings involved.

Since the initiation of GENESYS, new public universities offering engineering have been established in GENESYS eas, but they and GENESYS operate as if the other did not exist. Through GENESYS, the Gainesville campus could extend meaningful assistance to these developing programs that would simultaneously improve their quality and lower the cost to the State.

GENESYS does not presently reach into several areas of the State to which it could render important service, notably Tampa and Miami.

GENESYS's efforts to date appear to have been focused strongly on large companies and on aerospace and electronics subject matter.[1] Increased attention needs to be given to serving a broader spectrum of engineering activities.

When it started operations, GENESYS set up a number of administrative procedures regarding qualifications of students admitted to the program, comprehensive examinations, etc., to reassure everyone that the degrees obtained via GENESYS were not of inferior quality. ow that GENESYS has proven successful and is accepted, existing res ctions should be reviewed and many of them modified.

GENESYS facilities presently find only minimal use in non-credit, continuing education programs and related activities. In this connection, an organization such as ACE (Association for Continuing Education), a side operation associated with the Stanford instructional TV system, could

[1]This is supported by an analysis of GENESYS enrollment data for Spring 1971 at the Orlando Center. Of 97 enrollees in talkback television courses, 83 were employees of either Martin-Marietta or Naval Training Devices Center, one each was from Bendix, FMC, and C'Neal Associates. Eleven were unaffiliated (i.e., unemployed). There were also 8 enrollees at Dynatronics (a General Dynamics subsidiary located outside of commuting range) who were receiving instruction in an experimental videotape system.

perform a useful service to industry in Florida.

The GENESYS studio classrooms and viewing rooms need in some cases to be upgraded and modernized to conform with the best modern practices; in particular, the viewing rooms should provide a relaxed living room or seminar room type of environment for small groups (up to 6 or 8).[1]

No really basic problems are associated with removing many of the above limitations. In some cases, administrative attitudes and procedures need to be changed. In others, it is merely necessary to get diverse people to realize that they have common interests and that it is to their mutual advantage to work together.

There will, however, be the necessity of investing some capital funds to exploit the new technologies; i.e., for ITFS broadcasting transmitters, additional and/or improved studio classrooms, videotape machinery, c. Such expenses are not of overwhelming magnitude and can be incurred step by step, so that capital expenditures in any one year can be kept to a moderate level.

The justification for a program of capital expenditures to expand and modernize GENESYS is that in this way annual operating expenses can be substantially reduced, while concurrently increasing both the quality and quantity of service that is rendered to Florida industry and to Florida engineers employed in industry. A further justification for capital expenditures is that a revitalized GENESYS system will make it possible to avoid incurring certain annual expenditures in the academic budgets of cooperating institutions. This saving occurs when courses are shared simultaneously by several institutions, instead of duplicated on each campus as would otherwise be the case. The savings possible from such interinstitutional cooperation offer the possibility of easily repaying the capital investment over a five-year period.

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[1] An example of the wrong type of environment is represented by one to three students sitting in a large austere Center classroom made to accommodate 50 students. An even less attractive arrangement was observed by the writer at Florida Atlantic University, where one lone student sat in an open space in a cavernous audio-visual production room filled with a disarray of equipment, and open to anyone who happened to wander through.

3.6 Suggested Plan for Action. *Objectives.* A program for revitalizing GENESYS should give high priorities to: (*a*) maximizing the number of industrial employees who are potentially available as GENESYS students; (*b*) making GENESYS courses as accessible as possible to prospective students; (*c*) emphasizing quality in the course offerings; (*d*) encouraging interinstitutional cooperation that enables recently established engineering programs to benefit from the academic strength at Gainesville and reduces the need for different campuses to duplicate low enrollment courses; (*e*) expanding GENESYS coverage and clientele by interesting more companies and more engineers in this service and by increasing the scope of course offerings; (*f*) doing all of this at minimum cost to the State in relationship to services rendered, considering both capital expenditures and annual operating costs.

General Approaches to Implementation of Objectives. Objectives (*a*) and (*b*) involve the broadcasting of GENESYS signals over ITFS channels so that GENESYS classes are available to industrial employees at their places of employment; in the case of locations beyond broadcast range, they involve using videotape recordings of GENESYS signals.[1] Objective (*c*) requires that a large majority of GENESYS courses in the next five years originate at Gainesville, and that the channel capacity out of Gainesville be sufficient to make this possible.[2] As a corollary, any engineering course offered at Gainesville that is needed by GENESYS should be regarded as available to GENESYS.[3]

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[1]In this connection, it is to be noted that a combination of 200-ft. transmitting and 50-ft. receiving antenna towers gives a range of 25-30 miles, while doubling these heights adds an additional 40% to the range.

[2]If all programs originated at Gainesville, the present system could be rearranged to provide two channels by the expedient of reversing the direction of the south-to-north circuit. In addition, the University of Florida has devised a "slow-scan" arrangement that will enable two TV programs to be transmitted on each of the present channels. This system is reported to be entirely satisfactory.

[3]Faculty members who teach classes that appear on the GENESYS system should be given assistance in correcting papers, and other help as appropriate. The GENESYS classrooms should also be the most attractive and

Objective (*d*) will be achieved only by arranging matters so that the financial benefits and academic statistics resulting from interinstitutional cooperation are shared on an equitable basis by the cooperating parties. Thus, if the student credit hours of students receiving instruction over a TV system are credited entirely to the institution that supplies the teacher, then everyone wants to supply courses, and no one is interested in providing students. Under such circumstances, there will be very little cooperation.

It is important to note that the above several proposals are really part of a single integrated package. When GENESYS classes are broadcast, students do not need to commute to the Centers. This makes it practical for GENESYS to have 50-minute classes, which in turn makes it easier to schedule Gainesville classes on GENESYS, thereby making the quality of GENESYS classes correspond to the quality available on the UF campus. In addition, greater use of regular Gainesville classes reduces instruction cost to the State.

Objective (*e*) may require an increased number of channels in the system to accommodate more courses. It also calls for liaison work at the local level to identify potential needs of consumers not now being served by GENESYS and to develop their interest in making use of GENESYS.

There are a number of ways to minimize cost in relationship to service rendered (Objective *(f)* above). The <u>first</u> step is to transmit over GENESYS only those classes which would be taught anyway on a university campus in the absence of GENESYS. As pointed out on p. 58, the incremental instruction cost of adding GENESYS students under these conditions is negligible.[1]

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the best appointed on the campus. Under these circumstances, every faculty member should be as willing to have his class transmitted over GENESYS as he is to accept the responsibility of teaching a non-GENESYS class assigned to him.

[1]An incidental but by no mea[illegible]mportant side benefit of this arrangement is that it avoids relegat[illegible] GENESYS students to second-class status, as mentioned on p. 59.

Second, wherever possible, the existing GENESYS Centers should be closed, and the necessary residual operating functions and services transferred to a university campus in the area. The host institution could provide the office space, classrooms, viewing rooms, laboratories, library, janitor service, and other overhead functions at a small fraction of the cost required to maintain the present Centers.

Further, in such an arrangement, the only GENESYS staff required would be one half-time faculty member who would serve as a local GENESYS representative, student advisor, deputy registrar, etc., with the aid of a full-time secretary.[1] The other half of the faculty member's time could be absorbed by a faculty appointment at the host institution, and would carry with it normal half-time teaching responsibilities.[2]

The third methoa of reducing GENESYS cost in relation to the service rendered is to increase the service rendered. Since the present average size of GENESYS classes is small, the incremental cost of additional students is trivial; therefore an increase in enrollment would produce an almost proportionate decrease in cost per student credit hour.

Fourth, as interinstitutional cooperation is developed, GENESYS will make it possible for the State to slow down the increase in faculty billets in engineering otherwise required at the cooperating institutions, thereby avoiding very substantial expenditures. Thus, for each associate professor who need not be added to the faculty (or each vacant associate professorship which need not be filled) there is a saving in direct expense (including fringe benefits) of the order of $100,000 in six years; 10 such cases (i.e., two or three per institution) would thus save $1,000,000 in this period, which would finance a lot of capital facilities for GENESYS.

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[1] In contrast, the actual staff of the Orlando Center in the spring of 1971 consisted of 3 faculty and 4 FTE non-faculty, servicing 105 enrollees.

[2] This arrangement would also provide the GENESYS representative with a bona fide academic environment, which is largely absent in the present Center setup.

Finally, another way to reduce GENESYS costs is to make more use of adjunct faculty (lecturers) drawn from industry. Early in its history GENESYS made considerable use of adjunct faculty, but the practice has decreased in recent years. This change appears to be at least in part a response to incentives which entitle a department to add faculty members according to a staffing formula based on student credit hours. Under these circumstances, a department is entitled to replace each two or three adjunct professors (corresponding to one full-time-equivalent faculty member) by a regular faculty member. Since academic divisions are always hungry for more billets, the use of adjunct faculty has therefore been decreasing, even though this increases the cost to the State. In the fall of 1970, only three courses in the GENESYS system were taught by adjunct faculty.

Implementation. The implementation of a revitalized GENESYS system is preferably carried out in several stages. The first step would be to establish a new pattern of GENESYS operation in a selected region, and to accumulate experience on this operation. It appears that the West Palm Beach-Boca Raton region is the most promising location for this trial.[1] The idea would be to close down the West Palm Beach Center and transfer its administrative operations to Florida Atlantic University, while broadcasting GENESYS classes over ITFS channels to West Palm Beach students from a transmitter either at West Palm Beach, or at Florida Atlantic, or both.[2] This particular location has several desirable features: (*a*) there is already a GENESYS outlet at Florida Atlantic; (*b*) as Florida Atlantic expands into Electrical and Mechanical Engineering and begins to offer graduate work, it will greatly need the kind of help that can be provided by interinstitutional cooperation over GENESYS; (*c*) there is an important

[1]An alternative possibility would be Orlando.

[2]If desirable, it would be possible to maintain appropriate viewing classrooms somewhere in the West Palm Beach area for those students who did not have access to the broadcast signals. The broadcast coverage to be expected is indicated in footnote *(1)* on p. 62.

industrial area to the south of Boca Raton not now being served by GENESYS that is within broadcast range of FAU.

The second and longer range step would be initiation of an extensive systems engineering study to determine the best ways to improve the total operation of GENESYS. This study would involve a cost-benefit analysis of the many alternatives that are possible in a revitalized GENESYS system, including the costs and benefits resulting from extension of GENESYS coverage into new areas, such as Tampa, Miami, Pensacola, etc., and trade-offs between capital costs required to modernize and improve the system, and the resulting savings in annual operating expenses. Such a study should also include the relative desirability of leased lines versus a proprietary system, etc.[1] The channel capacity required for various links of the system should be determined, and possible tie-in with cable TV systems should be explored. The study should also investigate the use of videotape as against an ITFS relay station to extend service beyond broadcast range, and to handle some of the long-haul situations such as Pensacola. Above everything else, the experience already gained by institutions such as Southern Methodist University, Stanford, Michigan, CCNY, Colorado State, etc., should be studied and made use of. GENESYS is still based largely on the concepts and practices of the original 1965 system.

Such a study should be made by an organization or by individuals whose primary interest would be to define a workable, practical and economical system, and who had no prior position to defend or vested interest in the answers obtained. Those carrying on the study should also have the kind of imaginations that would lead to fresh approaches to educational problems.

Again, any study of the GENESYS system should explore the possibility of cooperation between public and private institutions in the State. It is conceivable a pattern of cooperation could be devised that

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[1]The Federal Communications Commission has recently established rules that permit the use of unattended low-powered inexpensive relay stations for ITFS systems; see FCC Report No. 6851, May 5, 1971.

on an exchange basis would benefit both public and private institutions, as well as their their respective clientele, without increasing anyone's budget, and possibly without even requiring a transfer of funds.

An intermediate step to be considered in any study involves establishing an ITFS broadcast system in Tampa which the University of South Florida would use to transmit daytime graduate classes to viewing rooms in industrial plants. Such a system would also provide a useful interconnection between USF's two campuses, and would make it possible to provide quality sophomore engineering courses to junior colleges in the area. The transmitting antenna for such ITFS broadcasts could be located either on a tower on the USF campus, or alternatively on a tower of one of the commercial broadcasting stations in the community, which could also house and service the transmitter at a nominal cost. If such a system were in operation, locally originated course offerings could be supplemented by videotapes of courses originated by GENESYS. In time, it would probably be found desirable for such a local system to be interconnected with GENESYS through either leased or proprietary circuits.

3.7 Capital Expenditures Will Be Required. Revitalizing GENESYS will require substantial, but not excessive, capital expenditures. However, if the plan suggested is followed, this will result in large savings through reduction in operating costs and avoidance of certain increases in academic budgets at cooperating institutions. The savings over a five-year period should be considerably greater than the capital expenditure required to upgrade GENESYS.

In connection with capital expenditures, it is recommended that the State assume responsibility for providing ITFS broadcast stations, additional trunk lines, new studio-classrooms, etc. The participating companies would be expected to provide their own TV receiving facilities, including talkback, and machines for playing videotapes.[1] In cases where

[1]Information on costs is given by C. A. Martin-Vegue, Jr., A. J. Morris, J. M. Rosenberg, and G. E. Tallmadge, "Technical and Economic Factors in University Instructional Television Systems," Proc. IEEE, Vol. 59, pp.

a special ITFS relay station was required to serve a particular firm, the industrial concern might also be expected to make a contribution, such as one-third or one-half, toward this item of expense.

3.8 Administration of GENESYS. In the early stages of interinstitutional cooperation, schools having new engineering programs, such as Florida Atlantic University, could be expected to lean rather heavily on Gainesville-originated classes received via GENESYS in order to supplement the quantity and quality of offerings that can be provided by a staff of relatively limited size. However, as such newer institutions develop their academic strength and expand the size of their faculties in engineering, they will in time become less critically dependent upon GENESYS and also will have more to offer the network.

A further factor in this situation is that each institution offering engineering courses will quite naturally and properly wish to be the focal point for engineering in its local geographical territory insofar as its public image is concerned. However, if GENESYS functions as a competitor that comes in from the outside and attempts to downgrade the importance of the local educational institution, intramural infighting accompanied by a minimum of interinstitutional cooperation can be expected as a matter of course.

Assuming that GENESYS moves in the direction of extensive interinstitutional cooperation, GENESYS must function as a utility that serves all public (and perhaps private) institutions on the same basis, without any exceptions. GENESYS cannot under such circumstances continue indefinitely as the fiefdom of a single institution.

Several possible methods of handling this situation are possible. A first step might involve setting up a GENESYS Commission consisting of the Vice Chancellor for Academic Affairs of the State University System of Florida as chairman, and the deans of engineering of the participating

946-953, June 1971.

Since commercial ITFS equipment is available, the costs for TV broadcasting and receiving installations are reasonable.

schools, and an equal number of representatives of the public interest.

Such a Commission would have the authority to establish operating policies and rules, would control budget policies, and could allocate each institution an appropriate geographical "home" territory. Actual operation of GENESYS within the guidelines of the Commission could be delegated to an individual institution.

In this connection, another matter in which real cooperation will be needed is with respect to degrees and the transferability of credit. If a new GENESYS pattern is established, there should be a plan by which credit earned in GENESYS courses would be applicable at any public institution within the State, and within reasonable limits the same should be true with respect to non-GENESYS courses. That is, a student in the Boca Raton area enrolled with the University of Florida through GENESYS should be able to count at least some courses taken at FAU toward the residence and unit requirements for a master's degree at the University of Florida. Likewise, a student enrolled for a degree at FAU should be similarly able to include GENESYS courses originating elsewhere in the system as though they were taken in residence at FAU. The principal requirement for degree programs of this type should be that they are coherent and of appropriate intellectual level. It should be immaterial to the finances of GENESYS and of the cooperating institutions where the student was enrolled for his degree or who granted the degree.

3.9 Local Institutional Responsibility in a Revitalized GENESYS System. A corollary of the above is that each participating institution will not only have the opportunity but also the responsibility of seeing that industry located within its own service area is fully aware of the potential of the combined resources available through GENESYS and the local institution. Under no circumstance should there be c ıpetition between GENESYS and the local institution in the latter's home area.

This will require that each participating institution establish active and continuing liaison with industry. Experience at Stanford and elsewhere has indicated that the initiative and leadership for such a program must come from the educational institution. It is also to be remembered that academic people are the ones best qualified to determine what education can and cannot contribute to industry, and that the academic people must take the responsibility for educating industry in such matters. The wrong way to proceed is to ask industry what it wants and then attempt to meet the resulting requests exactly as made. The trouble with this approach is that each firm wants something different, with some firms wanting things that are impractical to provide, while certain of the requests are incompatible with others. A better approach is for the educators to study industry's situation very carefully and, after determining its spectrum of needs, to devise the most practical compromise plan that it is possible to offer under the circumstances. This realistic program would then be presented as something the school could provide, and an expression of interest or disinterest would be requested. In this way everyone focuses on a common plan.

A comprehensive liaison program has various facets. Relations must be maintained with commercial firms, with the engineering community, and also with the general public. Special attention needs to be directed to members of top management who are in decision-making positions, and also to industrial division heads concerned with the recruitment and training of employees. It is necessary that the dean of engineering be personally and obviously involved in these activities. In addition, individual faculty members can help considerably by establishing close personal relations with their opposite numbers in industry.

3.10 Further Notes Regarding the Value to Industry of a Revitalized GENESYS System. In summary, it will be noted that a revitalized GENESYS system such as described, which places considerable emphasis on ITFS broadcasting and interinstitutional cooperation, would provide many features of value to industry. Such a plan would immediately improve the quality of the classes available to industrial employees who are part-time students, and would insure still further improvement with the passage of time. In addition, the subject matter coverage would be broadened; GENESYS service would be made available over larger geographical areas;

loss of employee time associated with commuting to a Center would be eliminated. More effort would also be made to bring small and local firms into the GENESYS activity.

These advantages of the proposed pattern for the GENESYS operation are obtained at very little additional cost to industry. At the same time, the cost to the State per unit of instruction received by students would be reduced.

3.11 Whither GENESYS? In this Chapter, the present GENESYS operation has been dissected and analyzed. Ways have also been suggested to exploit more fully the GENESYS technology for the benefit of graduate engineering education in Florida in general, and Florida's industry and employed engineers in general.

GENESYS is presently at a crossroad. While it offers great possibilities for solving an educational problem of major importance (i.e., the part-time graduate-level education of engineers employed in Florida industries), and of making long-term financial savings through interinstitutional cooperation, these results can be realized only by rearranging present operating practices, and by making an initial capital investment. It is not at all clear if the necessary actions are politically feasible at this time, irrespective of their logic.

GENESYS is at the moment faced with large cuts in its operating budget. These may very well result in a curtailment or deterioration in GENESYS from the present not entirely adequate operation. For example, it may be necessary to discontinue service in one or more geographical areas, thus reducing the number of students enrolled and increasing still further the GENESYS instruction cost per student credit hour. Alternatively, the GENESYS facilities might be shared with other users, such as education, medicine, etc. This would decrease the number of engineering courses available to GENESYS students, thereby making GENESYS less attractive and again reducing enrollment. In either case, the end result as far as engineering is concerned could at worst be a phasing out of GENESYS, or at best be a small scale and expensive operation that in fact made relatively little contribution to the needs of Florida industry for graduate education.

In facing up to this situation, it is necessary to recognize that it will be many years before the engineering programs at the newer public institutions will be able to provide their respective geographical areas with graduate education of the quality now obtainable through the combination of an updated GENESYS system added to the local resources. Graduate programs of outstanding quality are not created overnight, and it takes hard work, single-mindedness of purpose, and a considerable amount of money to do the job even in a decade.[1]

In summary, if GENESYS deteriorates in the next few years, or even if it merely remains static, the momentum that Florida has gained in serving the needs of industrially employed engineers will be lost entirely, and it will be difficult and expensive to reinstate this momentum in the foreseeable future. The chief loser in such a situation will be the State of Florida, since the industrial development that Florida fails to experience will take place elsewhere--in Phoenix, or in Dallas, on the San Francisco Peninsula, in Southern California, on Route 128, etc.

[1]This is indicated by the experience at other places. Thus all engineering schools rated in the top 20 in the country in 1969 had a very strong base with considerable national distinction 15 years earlier. Again, the engineering program at UCLA was started 25 years ago in a setting that gave it financial support comparable with that received by UC (Berkeley), and with the whole Southern California territory as its back yard, yet in the national ratings UCLA still trails a long distance behind Berkeley. Dean Thomas Martin of Southern Methodist University's Institute of Technology has made very substantial progress in creating a quality operation in five years, but the engineering budget at SMU has quadrupled in the process.

Chapter 4

REVIEW AND ASSESSMENT OF ENGINEERING EDUCATION IN FLORIDA

This Chapter presents a roundup and review of engineering education in Florida, with special attention focused on the opportunities and problems of the present and future.

4.1 Objectives of Engineering Education in Florida. Four principal objectives can be defined for engineering education in Florida. (*a*) The State should provide adequate opportunities for residents to obtain baccalaureate-level training in engineering in ECPD-accredited programs. (*b*) There should be master's programs available in engineering of character and quality that will adequately prepare Florida residents for the professional practice of engineering at something above a routine level. (*c*) Opportunities should be provided whereby employees of Florida's industrial concerns can obtain a master's degree level of competence, can update their knowledge, and can be brought into contact with new developments; such educational opportunities are not only important to the individual and his personal development, they are also essential to the health of Florida's science-oriented industry. (*d*) Florida should have at least one public institution that has a national reputation for academic excellence in engineering, ranking within the top 20 engineering schools in the country; in addition, one or two more institutions with at least some national visibility in engineering would be desirable and not out of proportion to the population and importance of the State.

It will be noted that the production of engineers, per se, for the purpose of meeting the manpower needs of Florida industry is not an all-important goal. Florida industry can recruit the engineers it needs from all over the country. However, if Florida fails to give these engineers opportunities to improve their capabilities and to keep up with new developments, Florida industry will tend toward labor-intensive rather than brain-intensive activities. Experience has shown that modern high technology industry does not flourish when located in an intellectual desert (see Sec. 1.15).

4.2 Further Comments on Some of the Major Issues Relating to Engineering Education in Florida. *Capacity Available for Educating Engineers.* Florida institutions have enough capacity not only to handle easily the present flow of undergraduate engineering students, but also any increase in enrollment likely to occur in the next five years. Accordingly, there is no need to initiate engineering programs at new institutions for some time to come; in fact, if one could start over and redo the past with the benefit of hindsight, there would probably now be only three instead of five publicly supported engineering programs in the State. The present need at undergraduate level is to achieve ECPD accreditation at the schools now without such accrediting (see Sec. 2.14, pp. 41-43), and to build up the enrollment at all institutions.

Graduate work presents a somewhat different set of problems to Florida. While there is no lack of physical plant capacity or of desire on the part of individual institutions to develop graduate work, it will take considerable time, perhaps a decade, before the newer institutions can from their local resources provide graduate course offerings in engineering having quality and breadth comparable with the course offerings available at the University of Florida (and thereby available through GENESYS). This situation makes interinstitutional cooperation through GENESYS particularly important, and means that newer institutions standing alone without the aid of GENESYS cannot provide the opportunities for graduate work that Florida industry requires.

Need for Quality. As repeatedly pointed out in this report, a critical need of engineering education in Florida is greater quality (thus see Sec. 2.5). The University of Florida, which has the only nationally visible engineering program in the State, should strongly focus its attention on further improvement of faculty quality. Each of the newer public institutions should also concentrate on developing faculty strength in carefully selected areas in order to obtain a measure of national recognition.

Quality is achieved through careful and consistent long-range planning which concentrates on doing a limited number of important things very well. Proliferation of curricula and courses in order to do everything for everyone is invariably achieved at the expense of quality. A practical strategy for achieving academic excellence is outlined in Appendix B. While Florida cannot hope to achieve broadly based outstanding quality in engineering overnight, it can, however, begin to take actions now that will in time lead to highly regarded engineering programs in a number of its institutions.

Need for a Functioning Deans Council. It would seem desirable to have a functioning Council of Engineering Deans in Florida. This should be primarily for the purpose of facilitating coordination of plans, programs, and ideas among the public institutions offering engineering; however, deans of private schools should be invited to attend and allowed to participate fully in the proceedings, although they should perhaps not vote on matters that affect only the public institutions. The Council should meet at least semiannually with the location of the meetings and responsibility for preparing agendas rotated. At any particular meeting, the chairman could be the dean of the host institution.

Time To Obtain the BS. The length of time required to obtain a BS degree in engineering at Florida's institutions of higher education should be reduced, so that at least 50% of those who enter without subject matter deficiencies will graduate in the prescribed 12 quarters (or 8 semesters). This is a goal that can be achieved, but to do so at certain institutions will require a major reorganization of the curricula, a reduction in the number of required units, and greater freedom to make substitutions for nominally required courses. In carrying out these changes, the attitude should be that the institution will give its average students the best grounding in engineering that can be achieved in 12 quarters, then will encourage the more successful ones to continue on for master's degrees.

Undergraduate Advising. Experience indicates that nearly all of the students who receive a BS in engineering were heading for engineering at the time of high school graduation. Engineering curricula are highly articulated, involving a tightly sequenced general preparation in the first two years, followed by greater subject matter specialization in the junior and senior years. It is therefore important to have an effective advising system specifically for engineering students that extends down to the preregistration period of the entering freshmen. In situations where all freshman and sophomore students are enrolled in a "University College," it is essential that the advising of students who have indicated their preference for engineering be under the direct control of engineers from the very beginning. If this is not done, the inevitable result is numerous botched-up programs that penalize students by adding to the length of time required to obtain bachelor's degrees. Much experience is available in the country with advising systems that put all freshman and sophomore students into a general pool, and this arrangement has been consistently found unsatisfactory for the engineering students when there is no direct contact with the engineering faculty from the very beginning of the students' college experience.[1]

These comments on lower division advising are particularly applicable to the University of Florida.

Upper division advising must be well-organized and given adequate attention. However, even though good upper division advising takes appreciable faculty time, it is relatively straightforward if the lower division advising has been well done.

Junior College Articulation. Special attention needs to be given to the problem of the junior transfer student heading toward a bachelor's degree in engineering. Although this subject was not studied in detail, evidence obtained indicates that a fully qualified junior-level transfer is unlikely to obtain a BS in engineering in six additional quarters. The facts on this matter need to be obtained at each institution, and analyzed to determine where the principal difficulties lie.

[1]Thus the College of Engineering at UCLA, which went on a upper division basis some four years ago, quickly found the arrangement unsatisfactory and has recently abandoned it.

In any case, the problem of articulation between junior and senior colleges will need to be given continuing attention. There should be a two-way understanding as to the contents of each freshman and sophomore course that is prerequisite to full junior standing at the senior college. This understanding must represent an agreement negotiated between equals; if the senior colleges treat the junior colleges as inferiors and attempt to dictate unilaterally as to what is expected of them, lack of cooperation will be an automatic consequence (see further discussion in Sec. 2.13).

It is to be antipated that many junior colleges will have difficulty offering sophomore-level engineering courses equivalent to those routinely taken by sophomores at senior institutions. This situation could be alleviated by the use of GENESYS and videotape techniques that would make these courses, as given at the senior institutions, available to students at junior colleges on a credit basis.

Junior college transfer students present a special and rather difficult advising problem to a senior college. Separate provision for handling such students should be made, and the most capable and most dedicated advisors available should be assigned to this very important task (see also Sec. 2.13, p. 41).

Master's Degree Considerations. A properly qualified master's degree candidate who does satisfactory work should normally be able to receive this degree after three quarters of equivalent full-time study. Florida institutions should develop statistics to determine whether this is actually the case. Because undergraduate students are systematically held at institutions longer than the advertised time, there is more than a suspicion that the master's degree program may, in fact, be longer for the average student than the one academic year advertised.[1]

[1]Thus 12 units per term are used in determining the number of equivalent full-time students in Florida's staffing formula, but at the University of Florida a total of 50 units is required for the Master of Engineering degree (54 units at Florida Atlantic). A double standard is obviously being used.

The wisdom of requiring a comprehensive examination in addition to course work when the master's degree is awarded without thesis is open to question, at least for part-time students employed in industry. The program of study leading to the master's degree, particularly for those who are employed in industry, should be tailored to fit the special needs and interests of the individual. On the other hand, if there is a comprehensive examination to be passed, then even if it has optional parts, the examination (and options) will be designed for the student who has followed a particular pattern of courses, and the advisors of graduate students will inevitably mold their advisees' selection of courses in ways that are dictated by the examination to be passed, rather than in the way that will be best for the students.

Finally, if a student has followed the pattern of courses recommended by his advisor, and has passed these courses with satisfactory grades, but subsequently fails on a comprehensive examination, it isn't entirely clear that the student is responsible for this result. One can argue that the failure should be charged either to the professor who gave the satisfactory grades, or to the faculty advisor who recommended the pattern of courses that failed to prepare the student for the examination, or else to the persons who made out the various parts of the examination. In this connection, it is to be noted that schools such as Stanford, California Institute of Technology, Michigan, and Illinois award MS degrees on the basis of course work alone, without thesis, and without requiring a comprehensive examination. The national image of these schools does not appear to be tarnished as a consequence.

Small Classes. The engineering programs at all of the public institutions in Florida suffer from an unusually high incidence of classes with small enrollments. This is true not only on the campuses which have few students, but also at the University of Florida. Here, although the undergraduate and graduate enrollments are large, the number of curricula is so great and the proliferation of courses within each curriculum so extensive, that there are many many classes with indefensibly low enrollments (also see pp. 84-85).

The remedy consists partly in purging curriculum offerings of unneeded courses with low popularity, and partly in developing and enforcing policies regarding cancellation of classes with small enrollments. A strong effort, coupled with vigorous policing will be needed to put this matter under control and to keep it there.

4.3 Comments on Individual Institutions. The following sections contain observations and recommendations on individual schools that are intended to help place each situation in proper perspective.

Florida Atlantic University. This University has operated to date with only a single specialized undergraduate curriculum in Ocean Engineering. Enrollment as of 1969-70 was becoming large enough to make an efficient operation possible, even though as of 1969-70 this program was relatively inconspicuous on its campus (see Table 2-5). Florida Atlantic's real problems are ahead. In the present year it has started graduate work in Ocean Engineering as well as an undergraduate major in Electrical Engineering; next year it plans to add an undergraduate major in Mechanical Engineering. It is too soon to tell whether enough students can be attracted to these new undergraduate majors to result in viable operations. It is even less clear whether the graduate program in Ocean Engineering will be able to develop a student following of viable size; this will probably depend on the student support funds that can be mobilized.

In view of these circumstances, direct instruction cost per student credit hour at Florida Atlantic will undoubtedly rise during the next several years, and could get out of hand if enrollments in the new programs do not build up as expected. In this connection, a revitalized GENESYS could be of substantial help by providing much of the advanced undergraduate instruction in Electrical and Mechanical Engineering during the initial years of these programs when the numbers of students would justify only a small faculty.

As an upper division university, Florida Atlantic should exercise statewide leadership in articulating junior college and senior college curricula for engineering students. While this is not presently a critical matter at Florida Atlantic, there is considerable room for improvement, since current statistics show that most students entering from junior colleges require 7 quarters to complete the supposedly six-quarter curriculum; practically none do so in six quarters.

Florida Atlantic is located in a region where the local industry is more strongly oriented toward research (as against manufacturing) than is industry in most of the rest of Florida. This presents the institution with a strong challenge (and opportunity) to create new programs in Electrical and Mechanical Engineering that have really exceptional academic strength. The present is a good time to recruit promising faculty members; in addition, the institution should identify a limited number of engineers from industry who, in the capacity of adjunct faculty members, could provide high-quality courses at graduate and advanced undergraduate levels which would add breadth to the offerings available.

Florida State University. The Engineering Science program offered by Florida State University is a true Engineering Science curriculum. As such it is handicapped by being a "stand-alone" engineering specialty (see p. 12). Further, the educational background it provides the student is designed primarily to prepare him for graduate study, rather than directly for employment. At the same time, many high school students who are heading toward engineering do not know for certain which field of engineering they will ultimately choose, and at this stage in life very few know whether they will be interested in graduate work.[1] Moreover, neither high school students nor high school counselors are likely to have a very clear understanding of Engineering Science. As a consequence, the Florida State undergraduate program, which gives the entering freshman no alternative but Engineering Science with its concomitant implication of graduate work, has limited appeal. This is clearly shown by the statistics of Table 2-1; although FSU was the second public institution in Florida to offer engineering, the growth of this program has been disappointingly

[1]Spot studies have indicated that at least half of the engineering students who go on directly into graduate work after the BS do not make this decision until some time in their senior year.

slow, even though the program itself is entirely satisfactory.

The net result of this situation is that the contribution FSU makes to the State in engineering is minimal. At the same time, FSU's instruction costs are the highest in the State (see Table 2-7), largely because of very low enrollment in the graduate program (average of 5 students per class). Prospects for substantial changes in enrollment are not promising in view of past history, but unless the enrollment increases substantially at undergraduate and particularly at graduate levels, instruction costs per student will continue to be high.

As to the future, Florida State apparently has several alternatives. First, it can simply hang on and do the best it can while following the present pattern of operation; in this case, early ECPD accreditation should be sought. Second, Florida State might attempt to broaden its appeal by adding General Engineering, and possibly a major in a field such as Electrical Engineering. Third, this Engineering Science program could be discontinued; or, fourth, it might be transferred to a campus with a larger base of engineering, such as the University of Florida or the University of South Florida. If either of these last two alternatives should be selected, now would be a good time to act, since Florida State does not at the moment have a permanent dean of engineering.[1]

University of South Florida. University of South Florida offers a single General Engineering major which provides a limited opportunity to specialize in a particular engineering field. The number of BS degrees awarded has shown a steady year-by-year increase and within a few years should be in the range 125-150 BS degrees per year. Thus, the institution is not far away from the time when it could, if it desired, spin off several of the more popular specialties as separate majors, while retaining a General Engineering umbrella for handling those students having

[1]The latest word [as of July 6] from the Chancellor in Tallahassee is that a combination of the third and fourth alternatives has been chosen. The engineering program at FSU will definitely be discontinued as of the end of 1971-72, and certain remainders will be transferred formally to another institution, probably University of South Florida.

other interests. In the meantime, engineering at USF is achieving low instruction costs and high teaching productivity by its present pattern of operation, which includes avoiding undue proliferation of elective courses.

University of South Florida also offers a master's degree in General Engineering to a clientele that is largely part-time. The Tampa area has a considerable amount of industry, and therefore provides the potential for a large part-time master's degree program for employed engineers. However, the geographical dispersion is so great as to make it impractical to serve these industrial employees from any single location if the students must commute to one central point; this is true even when the graduate courses are offered in the evening.[1]

In view of these circumstances, it is recommended that University of South Florida establish its own educational television station, over which regular daytime engineering classes would be broadcast on ITFS channels, to be received directly in industrial plants where the part-time students work. In such an arrangement, offerings originated by the USF faculty could be supplemented and enriched by videotapes of selected GENESYS classes, and by the use of adjunct faculty drawn from industry.

The engineering faculty of the University of South Florida varies in qualifications from department to department as judged by publications, research grants received on a competitive basis, etc. Some groups are in a position to offer graduate work of adequate quality, and quite possibly even to award doctor's degrees. However, other faculty groups are relatively little involved in advanced work, and so should be strengthened if their master's degree programs are to be promoted.

University of South Florida has adequate space to meet any near-term growth in engineering that is likely to occur at either undergraduate or graduate levels.

In conclusion, it is to be noted that the University of South Florida

[1]As a consequence the present graduate offerings in engineering are divided between the St. Petersburg and the Tampa campuses of University of South Florida.

does not now have an accredited undergraduate program in engineering. Obtaining accreditation should be given a high priority. Concurrently, USF should focus special attention on building up its academic strength.

Florida Technological University. In spite of its name, Florida Technological University is a general university, not an institute of technology. It is too early to say how well the engineering program at this institution is taking hold, since the first freshman class entered in the fall of 1968. However, the total engineering enrollment for the fall of 1970 was 570, which is encouraging.

At the present time, FTU offers a single undergraduate major in General Engineering, with some opportunity for specialization in a pattern similar to that being followed by the University of South Florida. Because of this approach, instruction costs in engineering at FTU are on the low side, while faculty productivity is fairly high. It is too soon for FTU to seek accreditation of its engineering program, but this institution should follow through on accreditation at the earliest permissible date.

Graduate work in engineering has been authorized at FTU beginning in 1971-72; however, the present FTU faculty will need to be enlarged and strengthened considerably before it can from its own resources provide MS work that adequately combines the breadth and quality required to meet the needs of industries in the Orlando area for part-time programs. In the meantime, the institution could supplement its faculty by making liberal use of adjunct lecturers from industry. Also, if the necessary arrangements could be made, it would be desirable to provide additional graduate courses to FTU's clientele through GENESYS.[1] Such cooperation would have the further advantage of minimizing competition between GENESYS and FTU.

University of Florida. The University of Florida dominates engineering education in the State; as of 1969-70 it was the only Florida

[1] It would be a simple matter to transmit programs presently available at the GENESYS Orlando Center over an ITFS relay channel to the FTU campus.

institution awarding the doctorate in engineering, and it awards the lion's share of Florida's BS and MS engineering degrees. In ratings of academic quality, UF stands as high as any engineering school in the South outside of Texas. Though this is faint praise, it points both to a need of the South, and to an opportunity which the University of Florida could grasp by playing its cards carefully.

The University of Florida has in recent years substantially improved both its faculty and its physical facilities. A National Science Foundation Development Grant received in the middle 1960's made it possible to enlarge and strengthen the engineering faculty and increase the tempo of the graduate program. This accounts for the improvement in quality ratings that occurred between 1964 and 1969 (see Table 2-3); it also accounts for the increased number of MS and PhD degrees awarded in recent years (see Table 2-1). Concurrently, major improvements in the physical plant and equipment were made through State appropriations matched by federal funds.

These accomplishments gave the University's College of Engineering the capability of providing a better education for more students. However, enrollment projections made around 1963, upon which these plans were based, have not been achieved, largely because of new engineering programs subsequently established in Florida which have diverted engineering students to other campuses.

The University of Florida has a large enrollment in engineering at both undergraduate and graduate levels. However, the institution tends to be on the high side, as far as instruction costs are concerned, compared with most Florida schools, and the teaching productivity of its faculty is low (see Tables 2-7 and 2-8) because the engineering students at Florida are divided among an astonishing number of fields. Thus, the University of Florida offers instruction in 12 degree-granting engineering departments (including agricultural, which is jointly administered with the School of Agriculture), and awards bachelor's, master's, and doctor's degrees in 11, 13, and 10 fields, respectively. This is to be compared with the national distribution of engineering degrees shown in Fig. 1-3, in which 3 fields account for 64% of all bachelor's degrees, while 6 fields plus non-differentiated programs in General Engineering and Engineering Science include all but 7% of the bachelor's degrees. In fact, the University of Florida offers degree programs in more fields of engineering at each level than does MIT!

This proliferation of departments and curricula reaches the point of reductio ad absurdum in the case of Coastal and Oceanographic Engineering. In 1969-70, this department consisted of 7 faculty members (including one visiting faculty member) and offered a master's degree; it had a total of 6 student majors, but awarded no degrees whatsoever in the year.[1] The 1970-71 catalog lists 11 courses offered by the department (exclusive of research courses), or 0.5 courses per faculty member per term. Based on 1969-70 enrollment data, this corresponds to a teaching productivity averaging less than 14 student credit hours per faculty member per term. These faculty members are in fact carrying on a research operation that pays virtually all of their salaries but which adds only incidentally to the academic program beyond giving the individuals involved the titles and privileges (e.g., tenure) associated with faculty membership.

The faculty distribution by engineering field at the University of Florida is also unbalanced in relation to: (*a*) the importance of the individual fields, (*b*) the teaching output in student credit hours per department, and (*c*) the departmental degree output (see Table 4-1). Several fields, such as Nuclear Engineering, Chemical Engineering, Metallurgy & Materials, and Environmental Engineering are patently overstaffed.

It is clear that the College of Engineering at University of Florida should work toward a consolidation of its degree programs that would lead to a reduction in number of administrative units, and number of courses offered, and to a staff distribution that is more in accord with the distribution of the students being served. At the same time, it must be realized that this is a long-term project, rather than a matter that can

[1] In addition, COE offered a PhD as an option within Civil Engineering, but this option does not appear to be very active: in 1969-70 CE and COE together awarded only 1 PhD.

Table 4-1

UNIVERSITY OF FLORIDA

STAFFING PATTERNS IN ENGINEERING AND RESULTING CONSEQUENCES ON INSTRUCTION COSTS AND TEACHING PRODUCTIVITY

1969-70

Field	Size of Faculty[1]	Student Credit Hrs. (Qu. units)	Teach. Prod. SCH per Qu.	Direct Inst. Cost per St. Cr. Hr.	Degrees Awarded		
					BS	MS α	PhD
Administration	6.7	-	-	-	-	-	
Aerospace	9.0	3,410	126	$42.52	39	2	4
Chemical	17.0	3,862	76	70.00	29	10	3
Civil	12.8	4,323	113	40.80	34	11	1
Electrical	35.8	14,932	139	34.08	133	22	11
Engrg. Graphics	4.3	2,440	189	18.87	-	-	-
Engrg. Sci. & Mechanics	13.7	6,791	165	30.74	13	3	3
Industrial & Systems	16.8	9,461	188	24.40	66	23	7
Mechanical	18.9	6,841	126	30.89	47	13	5
Nuclear	13.2	1,517	38	107.85	15	9	7
Coastal & Ocean	6.0	286	16	50.05[5]	-	-	β
Met. & Materials	14.8	3,786	85	40.29	7	7	5
Environmental	14.9	1,545	35	61.67[5]	-	13	6
	183.9[2]				183[3]	113[4]	52

[1]Assistant professors and higher (head count), excluding visitors and adjunct.
[2]Incl. 2.7 on leave.
[3]Plus 8 in Agricultural Engineering.
[4]Plus 1 in Agricultural Engineering (but excl. GENESYS).
[5]These departments have most of faculty time charged against research funds.

- No degree program.

α Excl. GENESYS degrees.
β PhD in COE is option within CE.

Source: Questionnaire.

be legislated into immediate existence. However, ten years of single-minded persistence could accomplish a great deal toward streamlining the operation.

The College of Engineering of the University of Florida operates a very large sponsored research program (see Table 2-4), a program far larger than the combined total for all of the other engineering schools in the State. This research support is the basis of the large output of PhD engineers (37 in 1968-69, 52 in 1969-70, and 44 in 1970-71). Approximately 40% of the total research funds listed in Table 2-4 are derived from State and local government sources and from industry and are for public service work, a significant part of which has little or no academic value.[1] At the same time, this research is carried on largely by faculty members, many of whom have tenured appointments.

The College of Engineering as a whole is on the verge of being overstaffed. As previously noted, enrollment projections have not been met because of new engineering programs subsequently established at other Florida institutions. The NSF Development Grant also contributed to the problem, since it required that the faculty be expanded more rapidly than would otherwise have been the case. Again, the recent changes in the undergraduate curricula which will enable students to reduce the time to a BS degree will reduce the student credit hours per graduating student below previous levels. Still again, any GENESYS Centers discontinued because of budget cuts (see Sec. 3.11) will result in resident facult with University of Florida appointments being returned to Gainesville.[2] Finally, more staffing problems will be generated if the State's 1971-72 appropriition for engineering research is substantially below the 1970-71 figure, as is expected. Because this research is performed largely by faculty members, many of whom have tenure, it may be impractical to cut back the

[1]In this connection Dean Uhrig writes: "Most engineering research projects at land grant institutions [supported from other than federal funds] are concerned with helping solve the technological problems of the State and may have very little relation to the academic programs."

[2]This situation will be accentuated if and when the plans recommended herein for GENESYS are implemented (see Sec. 3.6).

number of people involved in the research in proportion to the reduction in research funds.

It should be noted that these possible staffing problems are the result of a combination of circumstances that have developed over a period of years, and for many of which the present dean has little or no responsibility, even though he will have to live with the situation.

The University of Florida's College of Engineering operates under a veritable thicket of regulations which subverts normal administrative operations into a game to be played against the system. These regulations originate in part with the State through over-rigid line item budgeting, over-reliance on general staffing formulas, etc. The situation is further aggravated by the central administration of the University, which adds its own regulations. On top of everything else, the College of Engineering has its own rules and practices. The final result puts a premium on a form of gamesmanship based on expedience and devious strategies. This entire structure appears to be focused on <u>protecting against possible abuses</u> rather than <u>providing incentives for doing the right things</u>, such as achieving an operation characterized by high quality, minimum cost, and maximum service to the State.

The University of Florida is currently giving serious consideration to establishing a Doctor of Engineering program along the lines described in Sec. 1.3. This move is in keeping with the times and should be encouraged; moreover, if properly set up, it could make a major contribution to the individuals involved and the industrial firms served by a revitalized GENESYS program.

Embry-Riddle Aeronautical University. This is a very highly specialized institution concerned with various aspects of aviation. Its operating income consists almost exclusively of tuition and fees, and it appears to accomplish a great deal with very limited resources.

The only engineering offered at Embry-Riddle is an unaccredited bachelor's program in Aeronautical Engineering which awards around 30 BS degrees per year from a curriculum that has almost no technical electives.

This, in combination with a small faculty and heavy teaching loads, causes direct instruction cost to be unusually low.

Because Embry-Riddle draws almost all of its engineering students from out of state (see Table 2-10), it interacts only nominally with engineering education in the rest of Florida.

Florida Institute of Technology. The Florida Institute of Technology is a private institution that concentrates on engineering and applied science. It offers an accredited BS curriculum and also an MS program in Electrical Engineering. In addition, it awards BS and MS degrees in Space Technology; plans are being made to transform this curriculum into a bona fide engineering program with a mechanical engineering emphasis.

Enrollment in engineering courses is such that by minimizing technical electives and supplementing the services of a small and hard-working "regular" faculty with part-time teachers, the institution is quite viable from an economic viewpoint. The part-time staff consists of adjunct teachers from industry and numerous part-time teaching assistants and instructors.

Florida Institute of Technology caters to a substantial, part-time, locally employed clientele at both BS and MS levels; in addition, most of the full-time-on-campus students are Florida residents. FIT therefore does interact with other engineering schools in the State, at least in the field of Electrical Engineering. Like other institutions, this school would be prepared to accept more students if more qualified applicants were available.

Of the three private institutions in Florida offering engineering, Florida Institute of Technology is the one that could make the most effective use of a working relationship with GENESYS. It is accordingly recommended that FIT, UF and the Chancellor's Office (of the State University System of Florida) explore this possibility to see if a working arrangement can be devised that would benefit the State of Florida, and also would represent a fair and practical arrangement at operating levels.

University of Miami. As the statistics in Tables 2-1 and 2-2 indicate, the University of Miami conducts a moderate-sized undergraduate engineering operation distributed over 5 ECPD-accredited curricula. It also has a smallish graduate program with students divided among four fields. However, in spite of this dispersion of students among a substantial number of curricula, direct instruction costs are not unreasonable and faculty productivity is fairly high (see Tables 2-7 and 2-8). This result is achieved by curricula in which the number of elective courses is limited, combined with moderately heavy teaching loads and faculty salaries that are a little on the low side.

The University of Miami's School of Engineering is the only engineering school in the Miami area, but it has benefited very little from this situation. For example, Table 2-10 shows that at undergraduate level, approximately half of its 1969-70 engineering graduates list themselves as from out of state; moreover, only a quarter live within a 25-mile commuting range, and these are reported to be largely Cuban-born.

The graduate program suffers because of its newness; it is limited in strength and in attractiveness. During the period 1953-65 when US graduate enrollment in engineering was growing steadily (see Fig. 1-2), and research funds were expanding, Miami for its own reasons limited itself to undergraduate engineering; it is now paying the price of having fallen behind the trends in engineering education.

Within the University of Miami, engineering is currently regarded as a questionable program. It lacks faculty strength as judged by research activity and graduate work. Financially the operation is marginal, and with rising costs and static enrollment there is a concern that its future financial situation will be even less satisfactory.

As a consequence, internal discussions are taking place at the institution regarding the future of its engineering program. Possibilities include: (*a*) continuing on as at present; (*b*) phasing out engineering entirely; or (*c*) reorganizing it by transferring peripheral activities (e.g., Biomedical Engineering, Ocean Engineering, and Architecture) to other parts of the University, and concurrently establishing a Department of General Engineering as part of a School of Natural Sciences.

The suggested reorganization plan appears to have considerable favor within University of Miami circles, but fails to face practical realities. Transferring such functions as Biomedical Engineering and Ocean Engineering to other divisions of the University will not improve the overall budget situation, but will rather merely conceal the costs of these expensive but small operations in much larger budgets where they will be less conspicuous. Again, making the School of Engineering a department in a School of Natural Sciences will inevitably severely weaken the image of engineering at the University of Miami, with consequent unfavorable effects on enrollment. Such an organizational structure when tried elsewhere has consistently resulted in engineering programs of low vitality; this is because the interests of engineers and natural scientists are different.

If engineering is to be continued at the University of Miami, and retrenchment is necessary, it is recommended that the School of Engineering be preserved as an organizational unit, but that the undergraduate and graduate engineering offerings be reexamined and reorganized. At undergraduate level it would be desirable to move in the direction of a strong General Engineering core, while retaining opportunities for limited options; in this way the number of engineering courses offered could be reduced. Concurrently, a study should be made of the educational needs of engineers employed in the Miami area, and a program of graduate instruction developed that was tailored to serve their needs with a minimum number of course offerings. The feasibility of providing an ITFS broadcasting system to make Miami's graduate program conveniently available to the maximum possible number of potential enrollees should also be considered. At the same time, the quality and variety of graduate offerings would need to be improved through the judicious use of carefully selected lecturers and adjunct faculty drawn from industry. It should be possible to provide at least half of the graduate offerings in this way at relatively low cost, and with adequate to excellent quality.[1]

[1] Such a pattern is followed in the graduate programs of institutions such as New York University, Columbia, etc., and seems to work out quite satisfactorily.

Chapter 5

ENGINEERING TECHNOLOGY EDUCATION IN THE UNITED STATES

Engineering technology education leading to the two-year associate degree has been well established through a long period of development. In recent years, four-year bachelor's degree engineering technology programs have developed quite rapidly across the nation in response to a strong demand from young people for bachelor's degrees at the technology level different from the industrial technology programs.

5.1 Definitions. In an attempt to avoid confusion over terminology, it seems necessary to define some terms rather carefully. The Engineers' Council for Professional Development defines engineering and engineering technology as follows:

> *Definition of Engineering.* Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.
>
> *Definition of Engineering Technology.* Engineering Technology is that part of the technological field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer.

The graduates of two-year engineering technology programs are usually called technicians and the graduates of four-year engineering technology programs are usually called technologists.

Industrial technology is closely related to engineering technology, and the two are frequently confused. Industrial technology is defined by the National Association of Industrial Technologists as follows:

Definition of Industrial Technology. Industrial technology is a baccalaureate degree program designed to prepare individuals for technical managerial, production supervisory, and related types of professional leadership positions. The curriculum, even though built on technical education, has a balanced program of studies drawn from a variety of disciplines relating to industry. Included are a sound knowledge and understanding of materials and manufacturing processes, principles of distribution, and concepts of industrial management and human relations; experience in communications skills, humanities, and social sciences; and a proficiency level in the physical sciences, mathematics, design, and technical skills to permit the graduate to capably cope with typical technical managerial, and production problems.

5.2 Objectives of Engineering Technology and Industrial Technology. The central objective of engineering technology education has been defined as follows:[1]

> This analysis has established the central purpose of engineering technology education to be support for the practical side of engineering achievement with emphasis upon the end product rather than the conceptual process. There are many overlapping areas but, in broad outline, the engineering technologist may be said to achieve what the engineer conceives. The technologist is usually a producer, the engineer is more often a planner. The technologist is valued as an expediter, the engineer is sought as an expert. The technologist should be a master of detail, the engineer of the total system. Hence we may characterize engineering technology education as follows:
>
> In contrast to engineering education where capacity to design is the central objective, engineering technology education develops capacity to achieve a practical result based upon an engineering concept or design either through direct assistance to an engineer, in supervision of technically productive personnel, or in other ways.
>
> Where the work of the technologist and the engineer are similar in kind they may be expected to differ in level because of the differences in mathematics, science and engineering science in their educational backgrounds. The development of methods or new applications is the mark of the engineer. Effective use of established methods is the mark of the technologist.

The objectives of industrial technology education are discussed carefully in a study, Industrial Arts/Industrial Technology, published in October 1969 by the Office of the Chancellor, Division of Academic Planning, The California State Colleges, and commonly called the "Banister Report" after the study chairman, Mr. John R. Banister. The Engineering

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[1] Engineering Technology Education Study: Interim Report, American Society for Engineering Education, Washington, D. C., June 1971, p. 16.

Technology Study[1] accepts the Banister material and quotes from page 42 of it along with other comments as follows:

> The key phrases for industrial technology education, according to the California State Colleges Report, are "occupying the mid-ground between engineering and business administration," and "emphasizing the applied aspects of industrial processes and personnel leadership." These objectives are sufficiently removed from "in support of engineering activities" to make necessary different curricular emphases in industrial technology from those of engineering technology. Both types of curricula vary over a wide range so that each is best described in terms of a "median" or "model" curriculum. Also, the emphasis upon "breadth" in industrial technology, which contrasts with "specialization" in engineering technology, can best be described in terms of broad curricular groupings, such as math-science-technical content versus non-technical content including management.

5.3 Technology Curricula. A typical four-year engineering technology curriculum contains approximately two-thirds as much mathematics, physical science and engineering science as does a bachelor's degree engineering program, and this material is taught with approximately two-thirds as much rigor in engineering technology as in engineering. Mathematics for the engineering program begins with the calculus, and for the technology programs (ET associate degree, ET BS degree, and IT BS degree) mathematics begins with college algebra.

The content of a four-year engineering technology curriculum is about 70% math-science-technical and 30% non-technical, whereas the content of an industrial technology curriculum is normally about 50% math-science-technical and 50% non-technical. The engineering science or technical science content of an industrial technology program is normally quite low when compared to an engineering technology program.

Typical distributions of subject matter in two- and four-year engineering technology programs are given in Table 5-1. Students of technology programs generally cannot transfer to an engineering program without remedial work in mathematics, physical science, and engineering science. A pre-engineering or an engineering transfer program is not the same as the first two years of a technology program.

[1] Ibid., p. 28.

Table 5-1

SUBJECT MATTER DISTRIBUTION IN TYPICAL
ENGINEERING TECHNOLOGY PROGRAMS

Field	Associate Degree (Sem. Hr.)			Baccalaureate Degree (Sem. Hr.)		
Mathematics & Natural (Physical) Sciences		15	(0.5 yr.)		22	(0.75 yr.)
Technical Science	*11e*	30	(1.0 yr.)	*18*	48	(1.5 yr.)
Technical Specialty	*19e*			*30*		
Communications, Humanities & Social Sciences		7.5	(0.25 yr.)		22	(0.75 yr.)
		52.5	(1.75 yr.)		92*	(3.0 yr.)

*The remaining 28 semester hours are shown as technical electives 16, and free electives 12.

e Estimated.

Source: Guidelines for Interim Criteria for the Accreditation of Baccalaureate Degree Programs in Engineering Technology, Engineers Council for Professional Development, October 1970.

5.4 Faculty. The Engineering Technology Study gives the following information on faculty differentiation:[1]

> Faculty characteristics provide an important means of distinguishing between the purposes of educational programs in the several technological categories. Essentially all teachers above the rank of instructor in schools of engineering possess master's degrees and a majority hold PhD's. New additions to the faculty will be mainly PhD's or doctorates in engineering because of research orientation. Faculties for baccalaureate programs in engineering technology should have a majority of engineers with practical experience relevant to the curriculum. Programs in industrial technology are less dependent upon engineers for instruction and may be staffed largely by majors in industrial arts and practitioners from industry including some who have had managment training or experience. Faculties of two-year technician education programs are more mixed

[1] Ibid., p. 31.

in character and depend upon the uniqueness of the program. It seems probable that faculty differentiation can and should be a major factor in distinguishing between the areas of technological education being considered here.

The ECPD Guidelines amplify the BS degree engineering technology faculty as follows:[1]

> Faculty [members] hold a technical degree in engineering, science, or technology, a predominance with the master's degree. Technology employment, rewards, and promotion criteria reflect emphasis on past relevant industrial experience, teaching, and program and laboratory development and operation.

5.5 Need for Technicians and Technologists. The Engineering Technology Study[2] gives some data on employment of technicians and technologists, and the need for improved educational opportunities as follows:

> *Manpower Trends and Projections: Majority Viewpoints.* There seems to be a consensus that for the next movement upward in production, industry will need an increased input of technicians and technologists. Based upon a Bureau of Labor Statistics Report of 1970 . . . , it is estimated that of approximately one million technicians now employed, about two-thirds perform work related to engineering activities. However, only a quarter seem to have as much as two years of post-high school education directed toward their employment. A large number of technicians (estimated by BLS at 1,200,000) will be sought by industry, government and other employers between 1966 and 1980. This need will be partly engendered by volume of product, but it is being enhanced by growing sophistication of equipment and processes that demand more than vocational skills for construction, installation, operation, production and maintenance. Technologists will also be used for standardized design, in sales, and in supervision of production, including opportunities in management.

> *Balancing Production Against Need.* Finally, it is recommended that engineering technology programs at the baccalaureate level be initiated only where conditions are favorable and the need is established. The rapid growth of college enrollments is due to terminate in another decade. We have already seen overproduction of certain professionals who were in short supply a few years ago. The present production of baccalaureate

[1] Guidelines for Interim Criteria for the Accreditation of Baccalaureate Degree Programs in Engineering Technology, Engineers Council for Professional Development, October 1970, p. 11.

[2] Engineering Technology Study, pp.49, 55-56.

technologists is so small that any problem of oversupply seems remote. However, it is well to balance enthusiasm for this new development with the recognition that the overall need for high level technologists cannot be measured until industry and government have had increased experience with their employment and their productive value. A gradual development of new programs with continuing evaluation of results will provide the opportunity to adjust the production of baccalaureate technology graduates to employment opportunities.

A different approach to need is contained in the following statement.[1]

Anticipated Need for and Development of Engineering Technology Programs. It seems reasonable to assume that industry's efficiency would be improved sufficiently by post-high school education of its technicians to justify employment of one-half with associate degrees and one-quarter with baccalaureate degrees. For one-half of the associate-degree engineering technicians to be graduated from institutions having ECPD-accredited programs would require a four-fold increase in the number of graduates and many new accredited curricula. For one-quarter of the technicians employed by industry to be employed eventually as graduates of baccalaureate-degree programs, and therefore to justify classification as technologists, would require a new educational development more than one-third as extensive as the present operation of engineering colleges. The magnitude of the educational tasks indicated at both the associate and the baccalaureate levels does not lead to great optimism that they will be achieved within a decade. Technicians will still have to be obtained by upgrading craftsmen despite the hidden costs of inefficiency and failure to make technical improvements that might otherwise be achieved.

[1]Engineering Technology Education Study: Preliminary Report, American Society for Engineering Education, Washington, D. C., October 15, 1970, p. 79.

Chapter 6

ENGINEERING TECHNOLOGY EDUCATION IN FLORIDA

6.1 Current BS Degree Programs in Engineering Technology. Data on enrollments and degrees awarded in engineering technology programs presently functioning in Florida are given in Table 6-1.

Table 6-1

ENROLLMENT AND DEGREE DATA FOR FOUR-YEAR ENGINEERING TECHNOLOGY PROGRAMS

Institution	Programs	1967-68	1968-69	1969-70	1970-71
Enrollments					
Florida A&M	3		113	109	129
Univ. So. Florida	1		-	21	99
Embry-Riddle	1		76	82	76
Degrees					
Florida A&M	3	-	-	6*	21*
Univ. So. Florida	1	-	-	-	10
Embry-Riddle	1	4	2	4	4**

*From baccalaureate level programs.
**To date, others are expected.

Source: Individual institutions.

The Embry-Riddle program is in Aircraft Maintenance, and it is an ECPD-accredited program.

The Florida A&M University technology programs are in Data Processing, Electronics, and Civil Engineering. The Civil Engineering enrollment is small. All three programs have been granted reasonable assurance of accreditation by ECPD.

The University of South Florida technology program is in Industrial Engineering, and it offers only the junior and senior years of a four-year curriculum.

6.2 Current BS Degree Programs in Industrial Technology. The only industrial technology program presently functioning in Florida is at the University of West Florida. Its enrollments and degree output in recent years are given in Table 6-2.

Table 6-2

INDUSTRIAL TECHNOLOGY PROGRAM AT
UNIVERSITY OF WEST FLORIDA

	1967-68	1968-69	1969-70	1970-71
Enrollment (upper division only)	4	29	50	73
Degrees awarded	1	18	31	41

Source: University of West Florida

6.3 Current BS Degree Programs Closely Related to Engineering Technology and Industrial Technology. There are several four-year programs in Florida that are closely related to engineering technology and industrial technology, but which because of distinctive features need to be considered individually. These programs are listed in Table 6-3, together with enrollment and degree data.

The "Scientific Option" of the Systems Science program at the University of West Florida is closely related to engineering technology. However, the faculty members insist it is engineering, and four of the six faculty members are engineers.

The Building Construction program at the University of Florida is difficult to classify in the context of the present study, but it is

Table 6-3

DEGREE AND ENROLLMENT DATA IN SPECIAL B.S. PROGRAMS
RELATED TO ENGINEERING AND INDUSTRIAL TECHNOLOGY

	1967-68	1968-69	1969-70	1970-71
Univ. West Florida:				
(Systems Science - Scientific Option):				
Enrollment*	18	32	37	41
Degrees	-	3	7	11
University of Florida:				
(Bldg. Construction):**				
Enrollment*		195	180	185
Degrees		94	87	95e
(Mechanized Agric.):				
Enrollment*	3	4	4	2
Degrees	← - - 2 or 3 per year - - →			

e Estimated.

*Juniors and seniors only.
**College of Architecture and Fine Arts.

Sources: Individual institutions.

certainly so closely related to engineering technology and industrial technology that it needs to be included in the listing.

Curricula for the construction industry have been considered by a special subcommittee of the Associated General Contractors of America, which developed a document entitled Educational Goals and Recommended Construction Curricula for the Construction Industry. This report recommends basic science 22%, basic and applied engineering 22%, construction 25%, management 16%, and socio-humanistic studies 15%. This is 69% technical and 31% non-technical, which is almost exactly the 70-30 ratio proposed for engineering technology. The Florida program is 66% technical and 34% non-technical. The AGE subcommittee offers the following summary statement with respect to the curricular pattern they recommend:

> Large portions . . . [of this curriculum] are engineering. It is recognized that some institutions may find it impractical for reasons of accreditation requirements, faculty experience and interest, or institutional facilities to offer construction in the College of Engineering. In any case it is intended that the curricula recommended herein be offered with no less rigor than the traditional engineering course of study.

A majority of the seventeen faculty members in Building Construction at the University of Florida are engineers (8 civil, 2 architectural), with three graduates of the Building Construction program at the University of Florida, two architects, and two with BS degrees in engineering but having master's degrees in other fields. Therefore, on the basis of the curriculum and the faculty, the program at the University of Florida should be classified as engineering technology. However, the 1970-71 catalog states (p. 207): "This four-year program is for students who are interested in preparing for professional careers in construction management, techniques, operations, products research and related areas in the construction industry, rather than in architectural and engineering design." As thus described, the program is closer to industrial technology than it is to engineering technology. A further comment on this matter is made on p. 108 of the present report.

The Mechanized Agriculture program at the University of Florida is extremely small; it is closely related to industrial technology and could be so labeled. The program was first offered in 1959, and the enrollment has ranged from 2 to 6 students over this time span.

6.4 Current Associate of Science Degree or Associate-level Engineering Technology Programs. Two-year engineering technology programs offered in Florida are listed in Table 6-4 which gives enrollment and degree data.

The Embry-Riddle program in Aeronautical Engineering Technology and both programs at St. Petersburg Junior College are ECPD-accredited. The four associate-level programs at Florida A&M University are Architectural

Table 6-4

ENROLLMENT AND DEGREE DATA FOR TWO-YEAR ENGINEERING TECHNOLOGY PROGRAMS

Institution	Programs	1967-68	1968-69	1969-70	1970-71
Enrollment					
Fla.Inst.Tech.	5		77	232	278
St. Petersburg Jr. College	2		200	200	200
Florida A&M	4*		48	53	53
Embry-Riddle	2		14	7	2
Degrees					
Fla. Inst. Tech.:					
Flight Tech				15	11e
Ocean.(Electron.)				34	
St. Petersburg JC					
Electronic Mechanical			35	35	35
Florida A&M					1**
Embry-Riddle:					
Aircraft Maint.			1	1	
Aero. Engr.		5	3	-	

e Estimated.

*Three other programs are included within the BS degree or baccalaureate-level engineering technology programs.

**Only one student has indicated a desire to enter the labor market; the others plan to continue their education in the upper division.

Sources: Individual institutions.

and Building Construction Technology, Computer Mechanics Technology, Transportation or Automotive Technology and Electrical Technology; they have been granted reasonable assurance of accreditation by ECPD.

Florida Institute of Technology has introduced two new programs in 1970-71 which have not yet produced any degrees. These are Aviation Electronics and Instrumentation, and Air Transportation, with enrollments of 13 and 4, respectively, in 1970-71.

6.5 Proposed or Planned Programs. An attempt was made to obtain information on new programs that are either planned, that have been proposed, or that are being talked about. The results of this effort are listed in Table 6-5.

6.6 Special Features of Present BS Engineering Technology and Related Programs in Florida. The BS degree engineering technology programs in Florida have produced very few graduates to date. The two larger programs are quite new and hopefully will soon start awarding degrees in significant numbers.

The concept of an upper division program for engineering technology and industrial technology which is not backed up by a corresponding lower division program on the same campus is not yet well established in the country and may involve rather serious difficulties in implementation. Historically, purely upper division programs in engineering have never been very successful,[1] and there is even less experience with the corresponding problems of upper division-only technology programs. Thus, Florida is faced with the necessity of pioneering this new frontier. Hopefully, the upper division engineering technology program at the University of South Florida will soon produce information which can help in defining the difficulties of the articulation problem and how they can best be handled. The situation to be avoided is a transfer program requiring five years to obtain the same degree that could be obtained in four years if these years were all spent on the same campus.

Florida A&M University has a different type of problem in that their

[1]Thus, see footnote on p. 76.

Table 6-5

B.S. DEGREE TECHNOLOGY PROGRAMS
UNDER CONSIDERATION

Institution	Program	Comments
	Engineering Technology	
Fla. Inst. Tech.	Air Commerce	Will open fall 1971 with about 30 juniors
" " "	Oceanographic	No starting date given
Florida A&M U.	All four existing associate-level programs to be increased to baccalaureate programs	Planned to start Fall Quarter 1971-72
Univ. West. Fla.	Systems Technology upper two years	Open early in 1972 hopefully
Univ. So. Fla.	Additional options upper two years	Desired with possibility of adding lower 2 years if necessary
Univ. Florida	General ET program with all 4 years and with a limited number of options	Desired
Fla. Tech. U.	General ET program with all 4 years and with a limited number of options	Desired
Fla. Atlantic U.	Upper two years as at Univ. So. Fla.	Desired
Embry-Riddle	Aviation Electronics	Interested in developing
	Industrial Technology and Technology-Related Programs	
Univ. No. Fla.	Industrial Tech.	Scheduled for 1973
" " "	Construction Management & Technology	Scheduled for 1973
Fla. Int'l. U.	Industrial Technology	No starting date avail.

incoming students have very low test scores. In a check of the records of their incoming students, the highest Florida Twelfth Grade Test score found was 396. One CEEB verbal-plus-math aptitude score of 1115 was found, but the next highest score was 829.

There is no four-year BS degree engineering technology program associated with a large four-year engineering college in Florida. Such an arrangement has many advantages now denied to the State of Florida, such as sharing faculty and laboratory equipment during the initial two years. In addition, every four-year engineering program has a significant lack-of-persistence problem with many interested students dropped annually. A large number of these students are eliminated during or at the end of the freshman year. With an Engineering Technology Department in the same college, a very large percentage of these engineering "dropouts" will find engineering technology to be just what they want, and will go on to ET degrees and successful careers in industry.

Even in the very best junior colleges, it is quite difficult to prepare transfer students for the junior year of an engineering technology program. As a result the upper division college must offer sophomore courses in some specialties. The normal pattern is far more apt to be two years at the junior college and three years at the four-year college. This is true because most applicants for a BS in engineering technology have some remedial high school work to complete in the junior college, and because most junior college and four-year college programs do not mesh perfectly. For these reasons, an upper division university is almost certain to end up offering almost three full years of a four-year technology program, unless it is located next door to a junior college offering such a program.

Chapter 7

ENGINEERING TECHNOLOGY EDUCATION IN FLORIDA: CONCLUSIONS AND RECOMMENDATIONS

This is the ideal time to develop a statewide plan for BS degree engineering technology education in Florida. There are now enough programs in existence to give experience on which to base further planning, but as yet there is no undesirable duplication of programs.

The programs already in existence do not appear to conflict or to offer duplication of effort. However, if everyone who is talking about engineering technology actually starts such a program, there will almost certainly be undesirable duplication, small enrollments at individual institutions, and unnecessarily high costs to the State.

The following recommendations are submitted as potential building blocks for a Florida master plan in engineering technology, industrial technology, and related programs.

7.1 Recommendations for Individual Schools. *Florida A&M.* Ways should be sought to improve the academic quality of the incoming students at Florida A&M University, perhaps by State scholarships for adequately prepared candidates, as well as by an aggressive recruiting program.

Precise persistence data from initial enrollment to baccalaureate degree should be obtained for Florida A&M engineering technology students in order to determine more accurately the problems involved in admission of students with low test scores. Based upon these data, the admission policies for engineering technology should be revised as needed.

Necessary resources should be made available to develop current Florida A&M baccalaureate degree engineering technology programs to ECPD-accreditation levels; new BS degree programs should be added only after the present three are fully developed with adequate degree outputs and ECPD accreditation.

University of South Florida. The University of South Florida should be authorized to include an additional option as soon as the enrollment and degree output of the present option are adequate. There is no Mechanical Engineering Technology program presently in the State or planned, and this would be a good option to add.

After ECPD accreditation is obtained for the current option at the University of South Florida, and the enrollment and degree output are adequate for the second option, a third option may be justified.

In case the upper division plan at the University of South Florida and elswehere does not prove successful a complete restudy of engineering technology for the State may be necessary.

Embry-Riddle Aeronautical University. The Aircraft Maintenance program at Embry-Riddle is ECPD-accredited and probably adequate for the entire State. It is recommended that the State work out a funding arrangement with Embry-Riddle for Florida residents instead of starting a duplicate program anywhere in the State. It is suggested that the State pay the difference in tuition cost for each term successfully completed at Embry-Riddle over the tuition cost at a State school. This would almost certainly be less expensive to the State than offering a degree program of its own in Aircraft Maintenance.

University of Florida. Even though the Building Construction program at the University of Florida is not labeled "engineering technology," it should be so considered for master planning purposes. To duplicate this program with another program having an engineering technology label is considered completely unnecessary. The University of Florida should be encouraged to seek ECPD accreditation of this program, both for the advantages of accreditation and to make certain Building Construction is not overlooked in statewide planning for engineering technology.

University of North Florida. The Construction Management and Technology program being planned at the University of North Florida should not be approved, unless: (*a*) the program at the University of Florida is unable to enroll all Florida applicants, or (*b*) the program at the University of North Florida can be shown to serve a really different function, which now appears unlikely.

Florida Institute of Technology. The planned Air Commerce program at the Florida Institute of Technology should be given every encouragement and not duplicated elsewhere. A funding arrangement whereby Florida residents could enroll in this program at net tuition costs comparable with those at State schools should be developed. The State can no doubt pay the difference in tuition for much less than it would pay for a duplicate program having low enrollment prospects at a State institution. This funding arrangement might properly require ECPD accreditation of the FIT Air Commerce program at the earliest opportunity.

University of West Florida. The proposed Systems Technology program at the University of West Florida should be given serious consideration and further study. The administration of this institution is planning an <u>engineering technology</u> program, but a faculty committee has developed an <u>engineering</u> program. Due to geographic location and program content, it probably will not duplicate an existing program. Necessary revisions and adequate restrictions should be imposed prior to approval to insure implementation as an <u>engineering technology</u> program. Necessary revisions include: changing mathematical requirements and making a better division of the technical specialty content between the two years of community college work and the final two years at the University of West Florida. An engineering technology program is definitely recommended.

The existing Systems Science (Scientific Option) program at the University of West Florida requires modification because of the faculty viewpoint that this is an engineering program. The logical, feasible, and recommended solution is to direct or authorize the University of West Florida to develop its proposed Systems Technology program and its existing Systems Science (Scientific Option) program as two options of <u>one</u> engineering technology program, and have no engineering programs at the University of West Florida.

7.2 Establis ent of Four-year Engineering Technology Programs. It is recommended that one and only one four-year engineering technology program be established at a large four-year engineering college in the State.[1] An engineering college has much to offer an engineering technology program in terms of administrative and faculty support, advice, and encouragement, as well as mutual use of laboratory facilities for economy of operation.

Such an arrangement requires a separate Department of Engineering Technology with its own faculty to create a home for the engineering technology students. This arrangement further demands the full cooperation of the engineering faculty. Most freshman and some sophomore courses can be for both engineering and for engineering technology students where the engineering college has freshman and sophomore courses for its engineers. Most technology students are able to match the performance (or even exceed it) of the engineering students in common freshman and sophomore laboratory courses.

An initial program should have a general core with about three options, with additional options to be authorized after enrollment in the initial three programs is adequate and degree output is reasonable. More options should be added one at a time at a minimim of two-year intervals. Any option that attracts a large number of students could be allowed to split off into a separate program.

The most important recommendation is to authorize and start only one such engineering technology program and to do it after careful consideration of all possible factors.

Location of Proposed Four-year Engineering Technology Program. The location of such a program is very important and not an easy decision. The University of Florida at Gainesville is the logical choice from the standpoint of enrollment of engineering students, laboratory facilities, existing space, and the presence of a number of faculty members who are

[1] This situation with the entire four-year engineering technology program on a single campus is to be distinguished from the arrangement at the University of South Florida where the engineering technology program is an upper division activity fed by junior college graduates in engineering technology.

better qualified for teaching engineering technology than for teaching engineering. This faculty situation exists to some extent at most older engineering colleges. However, location at the University of Florida has two handicaps: (*a*) The present University College arrangement precludes adequate development of freshman and sophomore courses for either engineering or engineering technology students, and prevents the extremely important advising of these students by engineering and engineering technology faculty members. This is internal to the University of Florida and probably could be resolved with the proper input. (*b*) There is lack of a large industrial development close enough to the University of Florida to provide part-time employment for needy students. This might be resolved by an effective cooperative arrangement for engineering technology students with Florida industry.

The Florida Technological University deserves serious consideration from the standpoint of its location in a large metropolitan area and the absence of a University College arrangement to complicate its work with freshman and sophomore students. It almost certainly, however, does not have (because of the newness of its program) faculty members who are better qualified to teach engineering technology than engineering, and it is doubtful that FTU has surplus space and facilities for a potentially fast-growing engineering technology program. Also, FTU's enrollment is smaller than that at the University of Florida, which means it will have fewer students desiring to shift from engineering to a technology program.

Both universities have indicated their enthusiasm for being selected to start an engineering technology program that, as stated in the FTU proposal, "is designed to (*a*) accept beginning freshman students, (*b*) accept students who desire to transfer out of engineering, and (*c*) accept associate degree level transfer students."

Because of the extremely difficult faculty situation at the University of Florida and because of the availability there of adequate facilities, it is recommended that the University of Florida be selected instead of the Florida Technological University to start a four-year engineering technology program as soon as possible, provided the University

College arrangement can be modified to permit the Engineering Technology Department to control its freshman and sophomore students.

7.3 Miscellaneous Comments Regarding Certain Specialized Programs. *Engineering Technology in the Greater Miami Area.* Florida Atlantic University, another upper division university, is interested in starting an upper division engineering technology program to serve the greater Miami area. A check of the community college graduates from this area indicates the total is about 235 per year from the many engineering technology specialties involved. A knowledgeable community college leader in the area estimated that 80 to 100 of these might be interested in a BS degree program with perhaps 50 of them in Electronic Engineering Technology and the others widely scattered. Several other checks seem to confirm these data.

Since not all of these 50 could be expected to enroll at Florida Atlantic, and some would also fail to graduate even if they did enroll, it is recommended that no engineering technology program be authorized for the Miami area until firm evidence of a somewhat larger student demand is available. Enrollment data for the engineering technology program at the University of South Florida should be checked annually to see how many of their students are coming from the Miami area. At least two to three years should be allowed after the program recommended in Sec. 7.2 is in operation before making any move to start engineering technology at another institution. At that time, if the upper division programs at the University of South Florida and the University of West Florida are successful, and if enough students wanting engineering technology in the Miami area are available and unable to attend the other programs in the State, the establishment of an engineering technology program at Florida Atlantic University might be justifiable. Certainly Florida Atlantic University would appear to be the logical location for an engineering technology program if one were to be established in the Miami area, because of the support that its engineering school could provide.

Industrial Technology. The University of West Florida has the only industrial technology program, labeled as such, in Florida that has come to the writers' attention. The continuation of this program is recommended.

The University of Florida has a Mechanized Agriculture program that is closely related to industrial technology and could be so labeled. However the output is so small that the real question is not the label but whether to continue or discontinue. It is understood that no courses are taught solely for Mechanized Agriculture majors. If this is true, and if no courses are being kept alive solely for Mechanized Agriculture, then continuation of the program might possibly be justified. In general, the retention of any program with so few graduates is not recommended. In this case, it is recommended that the University of Florida be directed to present arguments and data to support either the continuance of the program or its termination.

The University of North Florida is considering the establishment of a BS degree program in industrial technology in 1973. Assuming proper planning for a quality program, approval is recommended. A program in engineering technology would not be recommended.

Florida International University is considering an industrial technology program. With only two other industrial technology programs (West Florida and North Florida), the establishment of an industrial technology program at the Florida International University would seem justified. It is recommended that the staff and faculty of Florida International University be encouraged to proceed with plans for an industrial technology program to start perhaps in 1974, or as soon thereafter as the initial success of the other two programs can be confirmed. A program in engineering technology would not be recommended.

Graduate-level Engineering Technology. The existing graduate program in Aeronautical Systems at the University of West Florida is definitely engineering-oriented. Some 75% of the faculty are engineers, and yet neither the administration nor the faculty claims that the program is an engineering program. It is probably the first master's program in engineering technology in the nation. It is recommended that this program be labeled engineering technology, and that there be exploration with ECPD regarding eligibility for accreditation as a first degree (since there is no undergraduate counterpart).

Appendix A

ECONOMIC CONSIDERATIONS IN ENGINEERING EDUCATION[1]

Critical Size in Engineering Programs. In order to be able to deploy its teaching resources effectively, an undergraduate engineering program should ideally graduate at least 40-50 BS recipients per year in each major. When this is the case, the courses which are required of all majors in a particular field but seldom taken by non-majors can either be given in one large section of 40-50 students, or in two smaller sections each of 20-25 students. At the same time, elective courses in the major taken by some, but not all, of the majors will enroll typically 15-30 students. In this situation, the average class size is easily maintained at a reasonable level, and flexibility is available in the use of the teaching staff.

This reasoning leads to the conclusion that the minimum economic size for an undergraduate program in engineering involving three or four principal majors (e.g., Civil, Electrical, Industrial, and Mechanical Engineering) is an output of 140-150 BS degrees per year. As the size of such an undergraduate engineering program falls significantly below this minimum economic size, the instruction cost per student credit hour can be expected to rise. Quantitative data supporting this deduction will be given later.

At the graduate level an analogous situation exists. The graduate-level engineering courses in the major field that an MS engineering student includes in his study program are usually taken only by majors in that field. Moreover, most of these graduate courses are elective. The result is that unless 40-50 master's degrees are awarded annually in a given major, many of the graduate classes in that major will be undesirably small, and therefore will represent high-cost instruction. The situation becomes particularly serious if the number of MS degrees awarded in the major is less than 20-25; then nearly all graduate courses in the major

[1]This material is exerpted from F. E. Terman, "Economic Factors Relating to Engineering Programs," Journal of Engineering Education, Vol. 59, pp. 510-514, February 1969.

specialty will have quite small enrollments. It thus follows that when an institution offers 3 or 4 principal majors in its MS engineering program, a total output of approximately 125-150 master's degrees per year will be required as a minimum if the instruction cost per student credit hour in the MS program is not to be excessive.

Effect of Size on Instruction Costs. Data on instruction cost per student credit hour confirm the fact that there is a minimum size below which instruction costs rise. Thus, the four University of California campuses in Part A of Table 1[1] have the same faculty salary scales, teaching loads, and patterns of operation, but differ in the size of their engineering programs. The small engineering operations *c* and *d* have much higher instruction cost indices than do the larger operations *a* and *b*. This is in spite of the fact that these latter engineering programs involve a higher proportion of supposedly expensive graduate work, make available to the student a wider variety of courses at both undergraduate and graduate levels, and likewise are considerably more prestigious.

Another comparison of similar schools is made in Part B of Table 1. The different California State Colleges all have the same policies as to faculty qualifications and salaries, teaching loads, lack of intensive involvement in research, and even the same staffing formulas. Here again, within a homogeneous system, but one quite different from that of Part A, the instruction cost index rises when BS output falls below about 140 degrees per year.

Instruction Cost of Graduate Work. The common impression that graduate engineering instruction is expensive compared with undergraduate instruction is not necessarily true. If the graduate program has an adequate number of students, as defined above, graduate classes can be about the same size as undergraduate classes. The direct instruction cost per

[1]The data in Table 1 are from the report, A Study of Engineering Education in California, by F. E. Terman, prepared for the California Coordinating Council for Higher Education and made public in May 1968.

Table 1

EXAMPLES OF INSTRUCTION COST INDEX, 1966-67
(in semester units)

Instit.	Instruc. Cost Index	Quality Grad.Prog.	Size BS	Size MS	Size PhD
A. University of California campuses:					
a.	$65	4	4+	4+	4+
b.	56	3	3+	4	3+
c.	76	2-	2	2	2
d.	89	1	1	1	-
B. California State College campuses:					
e.	$34	1	4	-	-
f.	35	1	3	2	-
g.	41	1	1	-	-
h.	43	1	1	-	-
i.	59	1	1	-	-

Codes

Code for quality of graduate program	Code for size	Actual degrees/yr. BS	MS	PhD
4 = Top 15 engineering schools	4	250-	200-	50-
3 = Top 30+ (but not top 15)	3	140-249	100-199	25-49
2 = Some national visibility	2	75-139	50- 99	10-24
1 = No national visibility	1	1- 74	1- 49	1- 9

student credit hour will then be about the same for graduate as for undergraduate engineering instruction, except as graduate courses are given extra weight when assigning teaching duties, and except when graduate courses are monopolized by the senior and hence higher salaried members of the faculty. While some will contend that graduate classes should be systematically smaller than undergraduate classes, there is no evidence to indicate that graduate engineering students require smaller classes in order to be able to learn than do undergraduate students in the same departments.

Master's Programs. When the MS degree in engineering is awarded without a thesis,[1] the instruction cost index of the MS program approximates that associated with graduate courses. As previously explained, this need not be very much greater than for undergraduate instruction.

Doctoral Programs. In doctoral work, no close relationship exists between the instruction cost index and size, such as is present in MS and BS programs. To the extent that doctoral candidates in engineering register for further classwork after completing the MS degree, they typically select additional MS level courses in their major field together with courses designed for advanced undergraduate and beginning graduate students in non-engineering fields such as physics, mathematics, etc. Thus, the formal classroom instruction of PhD students does not represent an important cost factor, provided a comprehensive MS program of adequate size exists.

The expenses of the faculty-student research activity associated with PhD programs in engineering are not ordinarily a major factor affecting the instruction cost index. Most doctoral research in engineering is supported by grants and contracts. Such funds pay direct expenses and, in addition, provide an overhead allowance. At most engineering schools, the time that faculty members devote to research and to the supervision of student research is also covered at least in part by a direct charge against the extramural research funds.

Are Too Many Schools Offering Engineering? A large majority of the engineering programs in the country are underpopulated with students, particularly at the graduate level. Thus, Table 2 shows that of the institutions having ECPD-accredited curricula in 1965-66, only half of those awarding the BS, and only a fifth of those institutions offering the MS achieved the minimum level of activity required for economic operation as defined above.

[1] At schools offering the PhD degree there is an increasing tendency to drop the MS thesis and concentrate student-faculty research at the doctoral level.

Table 2

SCHOOLS MEETING MINIMUM SIZE CRITERIA, 1965-66

Type of School	BS	MS
Schools offering degree (with ECPD-accredited curricula)	179	156
Institutions of min. economic size (UG = 140+, Gr = 125+)		
No. schools meeting this criterion	84	30
These schools as % of all offering degree	47%	19%
Degrees from these schools as % of all degrees	77%	59%

Note: Basic data from Final Report: Goals of Engineering Education, 1968 (ASEE).

At undergraduate level there are simply not enough students with the requisite ability and the desire to study engineering to go around. This situation can be expected to persist for many years to come, since it appears that undergraduate engineering enrollment will move upward only slowly. At the same time, new engineering schools are being opened every year, while very, very few close their doors.

At the graduate level, the situation is even more difficult and complex. Only a fraction of undergraduate students go on for graduate work. As a result the nation can support fewer graduate engineering schools than undergraduate schools, yet virtually every undergraduate program [not now offering the MS degree] is planning to expand into graduate work.

It is clear that there are more institutions offering engineering than are now needed by the country. In the competition for survival generated by such a situation, engineering schools that award 150 to 250 or more BS degrees and 100 or more MS degrees per year will have advantages over institutions that fail to meet these levels of operation. It is clear that at least a quarter of the institutions now offering the BS in engineering face very difficult times during the next decade.

Appendix B

STRATEGY FOR EXCELLENCE

The quality of the academic program of a college or university is determined primarily by the quality of its faculty and the extent to which this faculty is grouped into "steeples of excellence." Faculty quality in turn is a function of knowledge, scholarship, creativity, research competence, ability to communicate, and professional leadership. It is significant to note that impressive buildings and expensive equipment are not primary factors in determining quality. While a faculty needs space and equipment to carry on its work, space and equipment do not by themselves produce excellence!

Steeples of Excellence. The quality of a university as perceived by the world is determined principally by "steeples of excellence" in which each steeple is formed by a group of capable faculty members having closely related interests. The higher the individual steeple, i.e., the greater the academic strength in a particular area of knowledge, the greater the distinction involved. It is not at all important that an individual steeple of academic excellence cover a broad field of knowledge; what is important is that it be so high as to be easily visible to the entire nation. Neither is it important that there be many steeples; a few steeples that are very, very high and located in important academic areas provide far more distinction than a large number of moderately high steeples. These very high steeples also benefit the academic programs in related areas, make it easier to recruit faculty in all fields, and add vigor to the entire institution.

As an illustration of how the steeple concept works, an electrical engineering department will achieve much more national recognition if it has five good men, all of whom specialize in one of the important areas within electrical engineering such as solid-state electronics <u>or</u> control systems, compared with an electrical engineering department that has five equally good men distributed one in each of five fashionable areas of electrical engineering. The latter arrangement, in which individuals work without close colleagues, adds up to very little of significance; the former can give national distinction. It takes a critical mass of talent concentrated in an individual speci to make an impact on the world.

An implication of the steeple principle is that an engineering school, however wealthy, should not aim to be fairly good in everything. Rather, it should concentrate on a limited number of important areas and build the highest possible steeple in each. This is the policy that has been followed (either consciously or unconsciously) by nearly every outstandingly successful department and university in the country.

In applying the steeple principle, it is essential that each steeple represent an important area of knowledge. It is easy to build a steeple that deals with an exotic, unimportant, or dying field, but little is thereby gained. It is always tempting to seek a neglected area of knowledge and concentrate on it because the competition is weak; however, the payoff, too, is meager.

The Cost of Excellence. Excellence costs money, but can be less expensive than is generally appreciated. This is especially true when a desired upgrading of faculty can be integrated into normal long-range academic planning, instead of being simple additions to the head count. For example, a group of five faculty members, made up of two distinguished individuals with established reputations backed by three promising younger scholars to round out the team, will produce a significant peak of excellence provided all the individuals involved are truly outstanding. When such a group is built up through a combination of replacements resulting from retirements, deaths, and resignations, and the expansion that commonly occurs in a developing institution, the cost of acquiring the peak of excellence is nominal. At most, the additional salaries required to obtain outstanding men will not average more than \$5,000 to \$10,000 per year for each of the five positions; this represents an incremental faculty cost of \$25,000 to \$50,000 per year for a high steeple.

Department heads and others will often argue that it is impractical to concentrate the expertise of the engineering faculty in a small number of narrow specialties; they will claim that many courses which need to be taught do not fit the chosen steeples. However, a real expert in an important subfield of engineering can teach basic courses outside his specific research field.

Again, some administrators will contend that since a high-quality faculty will require lighter-than-normal teaching loads, building quality presupposes a substantial expansion of numbers. However, the actual fact is that by elinimating unnecessary courses, by holding down proliferation of course offerings, by simplifying the core curriculum, and in some cases by allowing individual lecture classes to be larger than have been considered normal, it is possible for a tough-minded department head or dean to accomplish a great deal in building peaks of excellence with little or no faculty expansion and at only nominal incremental salary expense. The writer states this categorically because he has seen a number of outstanding steeples of excellence built in this way.

The salary cost will, of course, be higher when it is necessary to create new billets as part of the plan for excellence, rather than merely to manipulate those billets that become available through normal academic turnover and expansion. Even then the number of new positions required to establish a high steeple need not be unduly large. Starting with v[illegible] build on, an annual incremental investment of $12-2[illegible] in salaries will after three years (total increment of $50,000[illegible] [illegible]sh a great deal.

Excellence can be achieved without a large number of faculty bodies. Thus in recent ratings,[1] Stanford's Chemical Engineering Department was ranked fourth in quality in the U. S. At the time these ratings were made, the effective strength of this department consisted of 4 professors plus 2 assistant professors without tenure. It is not the number

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[1]Kenneth D. Roose and Charles J. Anderson, A Rating of Graduate Programs, American Council on Education, 1970.

of men that counts; what is important is their average distinction.

Many will claim that excellence requires large outlays for research, equipment, and supporting personnel. Again, this contention greatly overstates the requirements. In science and engineering, faculty members who are really outstanding can fund all or nearly all their research expenses, including equipment, through research grants and contracts; in addition, supporting personnel over and above the support associated with normal teaching and related duties can likewise be provided through research funds.

At the same time, it is true that an institution must incur some additional costs in building excellence. A distinguished faculty expects better support for its teaching activities than does a mediocre faculty; able junior staff members may need "seed money" to get their research started while waiting for action on grant applications, or to lay a foundation for making application for grants; institutional help on research equipment is sometimes required in matching situations, etc., etc. Some of these costs, however, such as matching funds for equipment and seed money for research, are of a one-shot character, and the remaining costs can be kept moderate. In particular, there is no need for _continuing_ institutional support for the research of an individual faculty member in science and engineering fields; if a faculty member after getting established is not good enough at research to obtain government grants, there is little justification for using scarce institutional funds to support his research.

The space requirements generated by excellence are in another and sometimes difficult category. Excellence brings with it more funds for research, more graduate students, and need for more space. However, the capital cost of this space is a one-time expenditure, since maintenance of research space is covered by the overhead income associated with the research. Moreover, as each square foot of area in a research building will provide the space associated with an _annual_ research expenditure of the order of $15 to $45 under typical conditions, an investment in the space required to house an enlarged research program provides a high return in terms of graduate students trained and academic recognition.

This discussion can be summarized by saying that creating new steeples of excellence (or strengthening existing steeples) can be expensive or comparatively inexpensive depending largely on the skill w th which available billets and incremental funds are manipulated. In any case, the goal ultimately sought by an institution striving for national prestige is for each and every tenured faculty member to have national visibility.

This Appendix is adapted from material written by F. E. Terman for the Colorado Commission on Higher Education under a contract with the Academy for Educational Development, Inc., January 1967. It appears in the present form in the Academy for Educational Development, Inc., report Detroit Institute of Technology Today, Tomorrow, and in the Generation Ahead, 1968.

Appendix C

EXTRACTS FROM

ENGINEERING EDUCATION IN THE STATE UNIVERSITIES OF FLORIDA

The following paragraphs are based on the report of a panel of consultants (W. L. Everitt, Chairman, Paul Chenea, and Robert Saunders) who made a tour of Florida's engineering schools in late 1965 under auspices of the Vice-Chancellor for Academic Affairs, Board of Regents, State University System of Florida. This is not a complete summary of the Everitt report, but rather presents quotations and summaries of observations from it that relate to the present study. For convenience in cross-identification, page numbers of the corresponding material in the Everitt report are indicated. Further, the underlined headings correspond to section headings of the Everitt report.

<u>Introduction</u>. "For geographical and other reasons, the Florida setting seems to peculiarly demand extensive off-campus graduate programs." {*p. 2*}

". . .if the State of Florida is to move rapidly toward the established potential for the development of a modern industrial base, it must invest a much larger proportion of its available income in higher education and particularly in high quality engineering education." {*p. 3*}

"Experience has shown that well educated engineers are fully able to exploit their intellectual skills in many fields, including the development of new disciplines not known at the time of their university education.

". . . The quality of the faculty and the individual breadth of its members is of paramount importance." {*p. 4*}

<u>University of Florida at Gainesville</u>. This institution is described as having ". . . a well established tradition of graduate work in . . . [engineering]. However, by most national measures, its programs would not be rated as distinguished or strong.

". . . the current undistinguished status of the engineering programs at the University of Florida can be traced to the following causes:

"Lack of continuous adequate support in terms of operating funds. . . .

"Proliferation of the academic administrative structure, with the resulting fragmentation of academic goals and programs, which, in turn, tends to dissipate the already limited resources." {*p. 6*}

"A comprehensive study and a detailed analysis of the ways and means that the available resources can be brought to bear on a sharpened focus and objectives for engineering education at the University of Florida should be inaugurated at once, . . ." {*p. 7*}

<u>GENESYS Program</u>. "It is also clear after a short period of operation that the type of instruction purveyed [by GENESYS] is distinctly and pedagogically different from traditional classroom attendance, but given the right conditions, may be a first-rate educational experience." {*p. 8*}

"Costs for GENESYS operation are exceptionally high in light of the educational programs being carried out.

"The faculty located at the GENESYS centers do not feel that they are an integral part of the University, with resulting low morale and excessively high turnover.

"Facilities at Cape Canaveral, and presumably at the other locations as well, are completely inadequate in the library and laboratory areas, . . ." {*p. 9*}

". . .there are an insufficient number of TV channels to satisfy simultaneously the needs of the degree and the non-degree programs. . . .

"We do note that the experience to date with GENESYS clearly indicates that it can play an important role in both graduate and non-degree professional engineering educational programs." {*p. 10*}

"The GENESYS faculty should be relocated at an established campus where there exists the requisite scholarly atmosphere so important to continuous faculty development." {*p. 10*}

"A study, to be followed with experimentation and evaluation, should be inaugurated to determine ways and means by which the total potential of the GENESYS concept can be exploited in other fields and for other purposes." {*p. 11*}

"Studies should be initiated to determine how best to administer the coordination of programs offered through GENESYS with programs offered by the Continuing Education Division." {*p. 11*}

Florida Technological University. "The diversified set of industries and government agencies in the Orlando region are oriented toward production and operations, rather than research and development. This characterizes the kind of technical talent needed in their activities.

"The population of East Central Florida . . . will not exceed 1.6 million prior to 1976 by the estimates provided. . . ." {*p. 12*}

The consultants recommended that first attention at FTU ". . . should be directed to the development of sound programs in the humanities, social sciences, and . . . [natural sciences]," while "second priority should be given to the establishment of occupationally-oriented programs leading to baccalaureate degrees appropriate to the region, such as the engineering technologies." {*p. 12*}

"At such time as (a) the population density merits, (b) the industrial need is well established, . . . then consideration should be given to the inauguration of programs in electrical and systems engineering. At this same time, it may be desirable to transfer responsibility for the GENESYS program in East Central Florida to Florida Technological University." {*p. 13*}

University of South Florida. ". . . the current program . . . appears to be meeting a community need as part of an urban university." {*p. 14*}

"The industry base is broad. . . . However, the preponderance of activity seems to be in the manufacturing and operations aspects." {*p. 14*}

"The population base of the area from which an engineering school must draw its students will be adequate in the near future." {*p. 14*}

"The College of Engineering should continue to develop its programs, with an emphasis on quality, to meet the local needs.

"Because of the serious needs of local industry, consideration should be given to the development of technology programs in concert with the junior colleges of the area.

"Since there is a local demand and a need on the part of industry, the College should strengthen its master's programs and begin planning for the doctorate in the early 1970's or as the need is demonstrated." {*p. 14*}

"The College should give serious thought to the problems caused by proliferation of effort if a portion of its [engineering] operation occurs at remote locations such as the Bay Campus. On the other hand, this may be a suitable locale for the technology program. . . ." {*p. 15*}

Florida Atlantic University. "There is a well established industrial base in the region whose activities and products require a wide range of engineering functions with emphasis on research, development, design, and manufacture.

"The region served . . . by the Florida Atlantic University includes a population of the order of two million." {*p. 16*}

"A population and industrial base of size sufficient to react well with an engineering college has developed.

"The orientation of a great deal of the industry of the area toward research, development and design is of the type most likely to require advanced programs in engineering." {*p. 16*}

"First priority . . . at Florida Atlantic University should be devoted to strengthening in depth the programs in mathematics and science basic to engineering through the graduate level and particularly at the master's level.

". . . the next priority for the addition of an engineering program in the State System should be at Florida Atlantic University.

". . . The initial competencies of the faculty should include those with backgrounds in at least solid and fluid mechanics, electronics and electromagnetic fields, thermodynamics and systems engineering." {*p. 17*}

"Technology programs at the bachelor's level . . . should be developed in conjunction with area junior colleges.

"When Florida Atlantic University has developed a master's degree program [in engineering], it should take over the administration of the [GENESYS] program now carried out at the Palm Beach graduate center of the University of Florida." {*p. 18*}

<u>The University of West Florida</u>. "The University of West Florida should not plan an undergraduate engineering program until the need is more clearly demonstrated than is now the case." {*p. 20*}

"[Some] technology programs . . . should be planned for early implementation." {*p. 20*}

<u>General Observations and Recommendations</u>. ". . . A . . . population base of two million . . . [is appropriate when] one is talking about establishing an engineering college of more than the very minimal acceptable quality. . . . On this basis Florida should have three engineering colleges at this time." {*p. 24*}

"Serious study [should] be given to the role and scope of Ocean Engineering and Technology in Florida educational institutions, with care [taken] that proliferation of existing basic engineering programs [in this subject] be avoided." {*p. 25*}

There should be an organized ". . . state-wide Council of the deans of engineering, . . ." {*p. 25*}

"There should be no development of new engineering programs at the expense of on-going programs nor until the financial base for new programs is clearly evident." {*p. 25*}